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**BERNARD C. COTTON,  
166 WELLINGTON RD., ADELAIDE,  
SOUTH AUSTRALIA.**

**TRANSACTIONS OF  
THE ROYAL SOCIETY  
OF SOUTH AUSTRALIA**

**INCORPORATED**

**ADELAIDE**

**PUBLISHED AND SOLD AT THE SOCIETY'S ROOMS  
KINTORE AVENUE, ADELAIDE**

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**Registered at the General Post Office, Adelaide,  
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## **OBITUARIES**

TOM E. BARR SMITH, B.A.

### **Summary**

A life-member of our Society since 1925; he died on 26 November 1941 at the age of 78. Mr. Barr Smith was the son of Robert Barr Smith, one of the founders of Elder, Smith & Co., Ltd. He was a member of the University Council since 1924, and made large financial contributions to the University, particularly in providing for and housing the Barr Smith Library. He also facilitated much research undertaken by the Waite Agricultural Research Institute.



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## OBITUARIES

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### SIR GEORGE J. R. MURRAY, K.C.M.G., B.A., L.L.M.

Sir George Murray, Lieut. Governor and Chief Justice, passed away on 18 February 1942 at the age of 78. Although not a frequent attender at the Society's meetings, he was a Life Member since his election in 1925. He was Chancellor of the University for many years.

### SIR WILLIAM BRAGG, O.M., K.B.E., M.A., D.C.L., L.L.D., F.R.S.

With the death of Sir William Bragg, at the age of 79, the Society loses one of its most noted Honorary Fellows.

After a brilliant career at King's College, Isle of Man, and Trinity College, Cambridge, he came to Adelaide in 1886 as Professor of Physics, a position which he held until 1908, when he was appointed to a similar post at Leeds, later occupying the Quain Chair of Physics at London University.

He became K.B.E. in 1920 and received the O.M. in 1931. He was director of the Royal Institution and also of the Davey-Faraday Research Institution, and in 1935 was elected President of the Royal Society of London.

As a result of his brilliant researches in pure physics, radio activity, the structure of crystals and the application of X-rays to the structure of the atom, Sir William received many scientific honours, including the Nobel Prize in 1915.

He was elected an Honorary Fellow of our Society in 1910.

### SIR ROBERT W. CHAPMAN, C.M.G., M.A., B.C.E., F.R.A.S.

The death of Sir Robert Chapman, at the age of 75, occurred on 27 February 1942. The son of Charles Chapman, he was born at Stony Stratford, England, on 27 December 1866, coming to this country at the age of 10. After attending Wesley College he took the degrees of M.A. and B.C.E. of Melbourne University with final first class honours and scholarship in mathematics and physics. At the age of 23 he was appointed lecturer in mathematics and physics at the University of Adelaide. He was lecturer in applied mechanics at the School of Mines for some years, and after having been lecturer in Engineering at the University for 10 years was appointed the first professor of engineering in 1907. In 1910 he also was appointed to the chair of mathematics and mechanics in succession to the late Sir William Bragg, an office which he held until 1919. He retired in 1937 after 50 years of service.

In 1927 he became a C.M.G., and in 1929 the Institution of Engineers of Australia, of which he was a foundation member, awarded him the Peter Mial Russell Medal and in February of this year elected him its first engineering honorary member. He was the Institution's third Federal president.

From the University of Melbourne he received the Kernot Memorial Medal for the years 1926-30. Sir Robert was president of the Astronomical Society of South Australia and was elected a Fellow of the Royal Astronomical Society in 1909. He was a member of the council of the Australian Institute of Mining Engineers and in 1907 became president of the South Australian Institute of Surveyors, in 1913 president of the South Australian Institute of Engineers, and in

1920 president of the Australian Institute of Mining and Metallurgy. He was a member of the Councils of the University and School of Mines, and in 1939 succeeded Sir Langdon Bonython as president of the School of Mines.

He was a Fellow of the Royal Society since 1907; a member of the Council from 1914 to 1922, and again from 1939 to 1941. In 1936, on the occasion of the Society's Centenary, he delivered the Centenary Address on "The Past Work of the Royal Society outside the Domain of Natural Science."

#### JAMES HUGO GRAY, M.D.

James Hugo Gray was born in South Australia on 14 March 1909, being the eldest son of James T. Gray of Orroroo. He was educated at St. Peter's College, where he obtained a Leaving Honours Bursary in Medicine. As an undergraduate of the University of Adelaide he came under the influence of Prof. H. H. Woollard and decided to make anatomy his career. He obtained the M.B., B.S. degrees in 1932 and M.D. in 1933. After finishing his Medical course with a resident post at the Adelaide Hospital he demonstrated anatomy for a short time under Prof. H. J. Wilkinson before going to England to work under Woollard at St. Bartholomew's.

Between 1930 and 1933 he joined in four expeditions to Central Australia under the auspices of the Board for Anthropological Research of the Adelaide University.

He was honorary demonstrator in anatomy and cancer research fellow at St. Bartholomew's 1935-36, full-time demonstrator in anatomy at University College London, 1936-37, and senior demonstrator from 1937 until he was appointed Professor at St. Mary's. In all he published 18 papers of a medical or scientific nature, some in conjunction with Prof. J. B. Cleland and others. He died at Epsom on 20 December 1941 at the early age of 32.

#### DR. R. S. ROGERS, M.A., M.D., D.Sc., F.L.S.

Dr. Richard Saunders Rogers, whose death took place on 18 March 1942 at the age of 80 years, was one of the oldest Fellows of the Society, having been elected as far back as 1905.

As a recognised authority on the Orchidaceae of the Australian Region, Dr. Rogers was a worthy associate of those other medical Fellows of our Society, such as Sir Joseph Verco and Dr. R. H. Pulleine, who as amateur naturalists did so much to increase our knowledge of the fauna and flora of this continent. During his association with the Royal Society he contributed 25 papers of high merit to the Transactions as well as two others in collaboration, and two to the Royal Society of Victoria and one to the Journal of the Royal Society of Western Australia, all dealing with the orchids. Amongst the most interesting which he described was *Rhisanthella Gardneri*, a new genus and species of Western Australian orchid with underground flowers.

He also published an "Introduction to the study of Australian Orchids" in 1911, and contributed the portion of Part I of Black's "Flora of South Australia" dealing with the Orchidaceae.

He graduated as Bachelor of Arts at Adelaide in 1883, and at the time of his death was its senior graduate. At the age of 74 he was awarded the degree of D.Sc. on the merit of his published works on the Orchidaceae. Dr. Rogers was on the Board of Governors of the Public Library, Museum and Art Gallery for 44 years and President from 1929 to 1931.

He was President of this Society in 1921-22, Vice-President from 1914-19 and 1922-24, and a member of the Council from 1907-14 and from 1919-21.

#### DR. M. T. WINKLER

Dr. M. T. Winkler, who passed away on 13 May 1942 at the age of 60 years, was a Fellow of our Society since 1935, and an active member of the Field Naturalists' Section for many years earlier, being keenly interested in Botany.

# **SILLIMANITE, KYANITE, AND CLAY DEPOSITS NEAR WILLIAMSTOWN, SOUTH AUSTRALIA**

By A. R. ALDERMAN, Department of Geology, University of Adelaide

## **Summary**

The occurrence near Williamstown of a large deposit of fire-clay of exceptional purity and quality has long been well known in South Australia. The main mass of this occurs in and around Section 950, Hundred of Barossa,<sup>(1)</sup> where the clay has been worked extensively. R. L. Jack (1926) and P. S. Hossfeid (1935) have described and discussed certain aspects of the occurrence and a number of short references to mining operations have been published from time to time in "The South Australian Mining Review."

## SILLIMANITE, KYANITE, AND CLAY DEPOSITS NEAR WILLIAMSTOWN, SOUTH AUSTRALIA

By A. R. ALDERMAN, Department of Geology, University of Adelaide

[Read 10 April 1942]

The occurrence near Williamstown of a large deposit of fire-clay of exceptional purity and quality has long been well known in South Australia. The main mass of this occurs in and around Section 950, Hundred of Barossa,<sup>(1)</sup> where the clay has been worked extensively. R. L. Jack (1926) and P. S. Hossfeld (1935) have described and discussed certain aspects of the occurrence and a number of short references to mining operations have been published from time to time in "The South Australian Mining Review."

The country rocks adjacent to the clay deposit consist of a great variety of schists and gneisses with quartzites and marbles. The age of these rocks is still uncertain. They dip steeply to the east, and actually overlie a considerable thickness of ilmenitic grits and sandstones, which both Howchin (1926) and Hossfeld (1935) agree are the basal members of part of the Adelaide Series, *i.e.*, Proterozoic. Howchin believed that the observed sequence is the stratigraphic sequence and that the schists, gneisses, etc., which occur to the east of Williamstown, are therefore the lower members of the Adelaide Series in a metamorphosed condition. On the other hand, Hossfeld has maintained that the sequence in this particular locality is inverted and that the schists and gneisses are of Barossian age and, therefore, older than the basal grits of the Adelaide Series which they actually overlie.

Adjacent to the clay deposits the alteration of the surrounding rocks has been very severe. The structure has been largely obscured by intense metasomatic alteration, by pegmatisation and by kaolinisation. In my opinion the high degree of metamorphism of these rocks is local rather than regional. Away from the comparatively narrow belt of intense alteration the grade of regional metamorphism seems to be about that of the biotite zone.

### OCCURRENCE OF CLAY AND SILLIMANITE

Among the remarkable features shown by the clay deposit itself is the presence in it of large and irregular masses of sillimanite-quartz-rutile rock. Some of the larger of these masses may measure two or three feet across, and the weight may be as much as a ton, or sometimes much more. The relative amounts of the three minerals are very variable and random specimens show the following variations, given in approximate volume percentages: sillimanite, 98-47; quartz, 51-2; rutile, 3-trace. Usually some clay mineral is also present. It will be seen that some of these masses consist almost entirely of finely fibrous sillimanite, with some needles and bunches of fibres a half centimetre or so in length. Such a rock is almost pure white with specks of red rutile. The felted nature of the sillimanite and the absence of any directional arrangement give it an extraordinary toughness which has been a very big problem in its commercial utilisation (fig. 1). Most of the varieties richer in quartz are roughly banded, layers rich in sillimanite alternating with quartz-rich layers in which small kyanite crystals may occur. Strings of tiny grains of rutile sometimes give a pale pink colour (fig. 2).

<sup>(1)</sup> Unless otherwise stated, section numbers given in this paper are in the Hundred of Barossa.

The sillimanite rocks and quartz-sillimanite-gneisses, besides occurring as discontinuous masses in the clay, also form massive deposits in the neighbourhood of the clay at a number of different centres. Many of the sillimanite-poor varieties resemble ordinary quartzite very closely in the field and their distinctive character is shown only under the microscope.

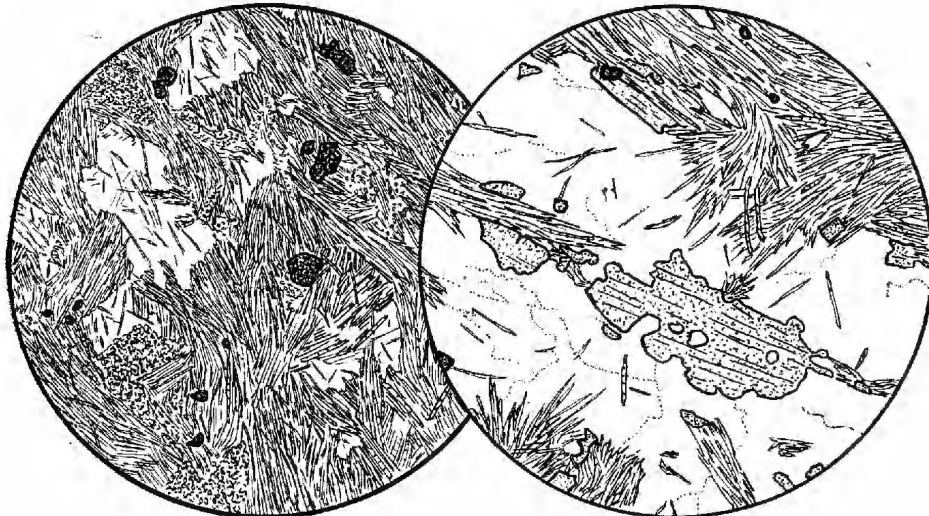


FIG. 1

FIG. 2

Fig. 1—Quartz-sillimanite-rutile-rock. (MC 5). Section 950. Consists of fibrous sillimanite and quartz with dark grains of rutile. Aggregates of fine granules of clay-mineral have developed from the sillimanite in some places.  $\times 25$ .  
 Fig. 2—Quartz-sillimanite rock. (MC 15). Section 950. The drawing shows a quartz-rich band in which kyanite has formed. A few grains of rutile are also present.  $\times 25$ .

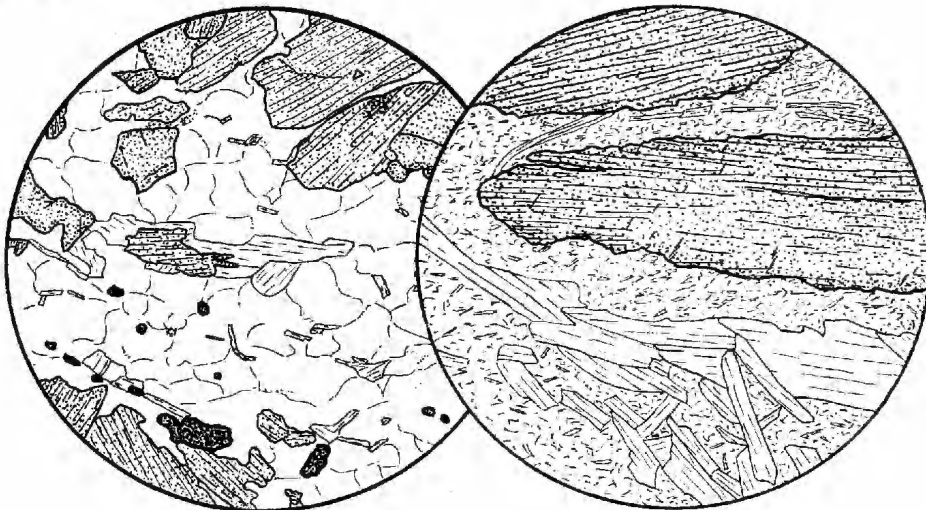


FIG. 3

FIG. 4

Fig. 3—Quartz-kyanite rock. (MC 69). Section 3101. In the centre of the field kyanite has changed to damourite, small flakes of which are also distributed throughout the quartz groundmass. Rutile is fairly plentiful.  $\times 25$ .  
 Fig. 4—Kyanite changing to damourite. (MC 1). Section 951. Large kyanite individuals are surrounded by a sheath of microcrystalline damourite. In the lower part of the field this has recrystallised to large flakes.  $\times 25$ .



A point which has formerly escaped notice is that a freshly broken surface of the clay shows exactly the same fibrous structure as the massive sillimanite, and there can be no doubt that the clay has been formed by hydrothermal alteration from sillimanite. In thin sections all stages in this process can be seen, the double refraction of the sillimanite fibres becomes lower, and they then become cloudy and eventually break up into very fine granules of clay, which is probably dickite. The clay always seems to contain some unaltered sillimanite. To confirm this, six samples of apparently pure clay from various parts of the deposit were examined, and all contained sillimanite fibres. This doubtless accounts for the excellent refractory qualities of the clay. Apart from some quartz, small grains of unaltered rutile are the only other normal constituents, although flakes of damourite derived from kyanite are sometimes very plentiful. The chemical compositions of typical clay and sillimanite-quartz-rutile rock, all from Section 950, are given in table A.

TABLE A

	CLAY (Jack, 1926)	CLAY (Jack, 1926)	Sillimanite-quartz- rutile rock ("Mining Review" 73, 1940)
SiO <sub>2</sub> ....	44.04	42.86	41.26
TiO <sub>2</sub> ....	0.52	0.04	2.70
Al <sub>2</sub> O <sub>3</sub> ....	44.74	47.96	54.35
Fe <sub>2</sub> O <sub>3</sub> ....	0.29	0.30	0.59
FeO ....	n.d.	n.d.	n.d.
MgO ....	nil	0.12	0.08
CaO ....	0.32	0.04	0.44
Na <sub>2</sub> O ....	0.39	0.18	0.02
K <sub>2</sub> O ....	0.19	0.41	nil
H <sub>2</sub> O+ ....	9.10	8.00	0.40
H <sub>2</sub> O- ....	1.00	0.60	0.02
CO <sub>2</sub> ....	nil	nil	nil
Cl ....	0.04	0.01	n.d.
	100.63	100.52	99.86
Molecular ratio: Al <sub>2</sub> O <sub>3</sub> : SiO <sub>2</sub> ....	1 : 1.67	1 : 1.52	1 : 1.29

Molecular ratios of Al<sub>2</sub>O<sub>3</sub> to SiO<sub>2</sub> show that in both samples of clay the Al<sub>2</sub>O<sub>3</sub> is in excess of the 1:2 ratio of dickite or kaolinite. This excess is accounted for by the presence of sillimanite, and occasionally of pale pink crystals of diasporite. In the third analysis, SiO<sub>2</sub> is in excess of the 1:1 ratio of pure sillimanite and suggests that about 9% of quartz was present in the sample analysed.

Sporadic patches and aggregates of small black tourmaline crystals are sometimes found in the clay. As I have not found these in the unaltered sillimanite-quartz-rutile rocks, it would appear that boron was introduced during the hydrothermal period when the sillimanite was kaolinised.

#### OCCURRENCE OF KYANITE

Kyanite is widely distributed in the area and occurs in a variety of ways. Pale green damourite has a similar wide distribution and its association with kyanite proves it, in most instances, to be an alteration product of that mineral. Some flaky damourite occurring in schists may have been formed by alteration of normal muscovite, but most of it comes from kyanite. In schists which have pseudomorphs of microcrystalline damourite after kyanite, the derivation is certain.

(1) Massive quartz-kyanite rocks occur adjacent to, and apparently marginal to, the massive quartz-sillimanite rocks referred to above. These also resemble quartzite in the hand specimens and can often be distinguished only in thin section from normal quartzite or from some of the quartz-sillimanite-rocks. Under

the microscope they are seen to consist of xenoblastic grains of kyanite in a granoblastic groundmass of quartz. A small amount of rutile is always present. The kyanite, which may constitute up to about 20% by volume of the rock, is usually concentrated in parallel bands and may or may not be elongated parallel to the banding. Some muscovite (damourite) is often present as an alteration product of kyanite. In these rocks the largest kyanite individuals rarely exceed 2 mm. in length (fig. 3).

(2) Kyanite occurs, generally with additional quartz, as veins and aggregates in the massive quartz-sillimanite rocks. The kyanite has generally changed partly or completely to damourite, this change being most advanced where the sillimanite of the host rock has been altered to clay. It would appear that during a hydrothermal period when much sillimanite was converted to clay, the kyanite was similarly changed to damourite. The kyanite-damourite veins and aggregates are sometimes very thin, though they frequently measure one or more centimetres across. In such cases they appear as bluish patches and bands in the white quartz-sillimanite rock, the kyanite individuals being a few millimetres in length and having no definite orientation. In rare cases the veins may be as much as a foot in thickness, as shown in the accompanying sketch (fig. 5). It is obvious in these occurrences that the kyanite veins were formed later than the sillimanite-bearing rocks. Rutile is a very constant member of these kyanite-damourite veins. To the south and east of the Warren Reservoir rutile occurs in quartzose veins and lenticles in massive damourite and has been mined, off and on, for many years. Although, as has been mentioned, rutile is finely distributed through the sillimanite rocks and their clay derivatives, the concentration of rutile is much higher in the kyanite-damourite rocks. The smaller veins and segregations are very plentiful in the sillimanite and at least some trace of kyanite can be seen in most specimens. This has had the effect of making a variable amount of damourite a very common component of the clay aggregate.

(3) Kyanite or pseudomorphs of damourite after kyanite are very common components of the micaceous gneisses and schists occurring near the margin of the massive quartz-sillimanite and quartz-kyanite rocks. The schists and gneisses have suffered a great deal of alteration and now appear as red-stained chloritic schists with a characteristic knotted and irregular weathered surface. The knots are damourite pseudomorphs after kyanite, and in thin section these rocks typically consist of bands rich in quartz with some orthoclase, finely crystalline damourite, and biotite which has largely changed to chlorite and much fine haematite. The rock has been a quartz-felspar-kyanite-biotite-gneiss. The depth and extent of the alteration suggest that the change has largely taken place during the pneumatolytic period, and thus contemporaneously with the kaolinisation of the sillimanite.

(4) Kyanite occurs as segregations in the kyanite-bearing gneisses and schists. These may be of the nature of veins, but their actual relations with the country rock are obscure. Most of this material now consists of damourite, and the change from kyanite to damourite is well shown in thin section (fig. 4). The kyanite first changes to microcrystalline damourite, which later recrystallises to

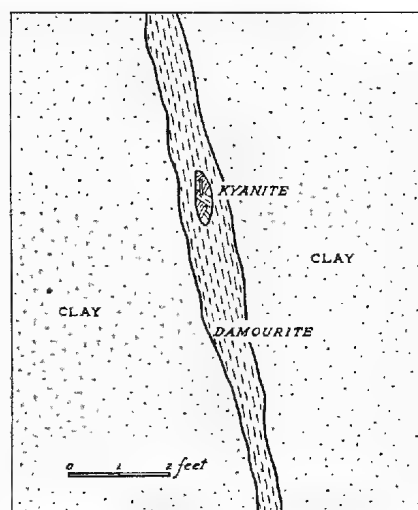


Fig. 5

Sketch showing occurrence of kyanite-damourite vein in quartzose clay (altered quartz-sillimanite rock). Quarry, Section 3,101.



the coarser flaky variety. In Section 942 these kyanite segregations consist of large unorientated blades, which may be several inches in length. Some of the masses are very large: one weighing over 400 lbs., and consisting of practically pure kyanite, was found by Mr. G. Warren, the owner of the land, and presented by him, with many other specimens, to the Geological Museum of Adelaide University. In Section 951, the kyanite was in places changed almost completely to finely crystalline pale-green damourite which has in the past been referred to as serpentine, and in fact greatly resembles that mineral. The highly aluminous nature of these segregations is shown by the presence of occasional pale blue crystals of corundum. Rutile is always present in varying amounts, but quartz is typically absent.

(5) Veins of kyanite with quartz occur in the schists and gneisses particularly in and around Section 959. Some of these kyanite-quartz veins contain a small amount of feldspar and they apparently grade into kyanite-orthoclase pegmatites. I have not found this latter rock *in situ*, but a large surface boulder found in the same locality by Mr. Warren consists of unorientated bladed crystals of kyanite, often two or three inches in length, in a matrix of orthoclase feldspar. This remarkable specimen, the dimensions of which are roughly 12 x 10 x 4 inches, is sufficiently large to give a very good idea of its origin, and I have no hesitation in regarding it as an example of a kyanite pegmatite.

#### DAMOURITE

Damourite is extremely widespread in the area, and its derivation from kyanite is, in most cases, certain. However, in some quartz-damourite veins and schists it is possible that it has been derived from normal muscovite. It occurs in two forms, one a fine-grained massive green type, which has been variously referred to as pinitic, greenstone, or serpentine; the other consists of pale-green non-elastic foliae and has sometimes been referred to as talc. In the alteration of kyanite the fine-grained type is first formed, and on recrystallisation the coarser foliated variety is developed. The identity of the two forms is established by chemical analysis.

TABLE B

	Fine-grained damourite, Section 3101. Anal. A. R. Alderman <sup>(2)</sup>			Coarse foliated damourite. Prob. Section 3101. Anal. T. W. Dalwood.			Damourite, N. Carolina, Dana (1899) p. 618	
	%	Metal atoms to 12(O, OH)		%	Metal atoms to 12(O, OH)			
SiO <sub>2</sub> ....	44.61	2.95	3.00	44.95	2.95	3.00	45.62	
Al <sub>2</sub> O <sub>3</sub> ....	38.62	3.01		39.48	3.04		35.93	
TiO <sub>2</sub> ....	0.02	—	3.02	—	—	3.01	—	
Fe <sub>2</sub> O <sub>3</sub> ....	0.98	.04		tr.	—		2.93	
FeO ....	0.24	.01		—	—		—	
MgO ....	0.11	.01		0.32	.03		0.34	
CaO ....	0.71	.05	0.93	nil	—	0.89	tr.	
Na <sub>2</sub> O .....	0.69	.08		0.98	.12		0.71	
K <sub>2</sub> O ....	9.54	.80		9.22	.77		9.40	
H <sub>2</sub> O+ ....	4.47	1.97		4.92	2.12		4.93	
H <sub>2</sub> O- ....	0.13	—	1.97	0.47	—	2.12	—	
	100.12			100.34			99.86	

It will be seen that with appropriate replacements by ions of similar dimensions the formula approximates closely to that of muscovite,  $KAl_3Si_3O_{10}(OH)_2$  or better  $KAl_2[Si_3AlO_{10}](OH)_2$ .

<sup>(2)</sup> TiO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub>, FeO, and H<sub>2</sub>O determined by W. B. Dallwitz.

The production of damourite from kyanite obviously requires the addition of silica, water and alkalis, mainly potash. The presence of corundum in the damourite may indicate either a silica deficiency in the converting solutions or an excess of alumina during the formation of the original kyanite.

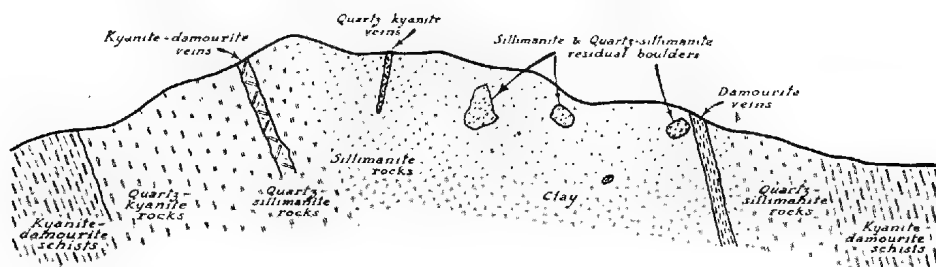


Fig. 6

Diagrammatic Section to show Relations of the Aluminous Rocks around Section 950. Not drawn to scale.

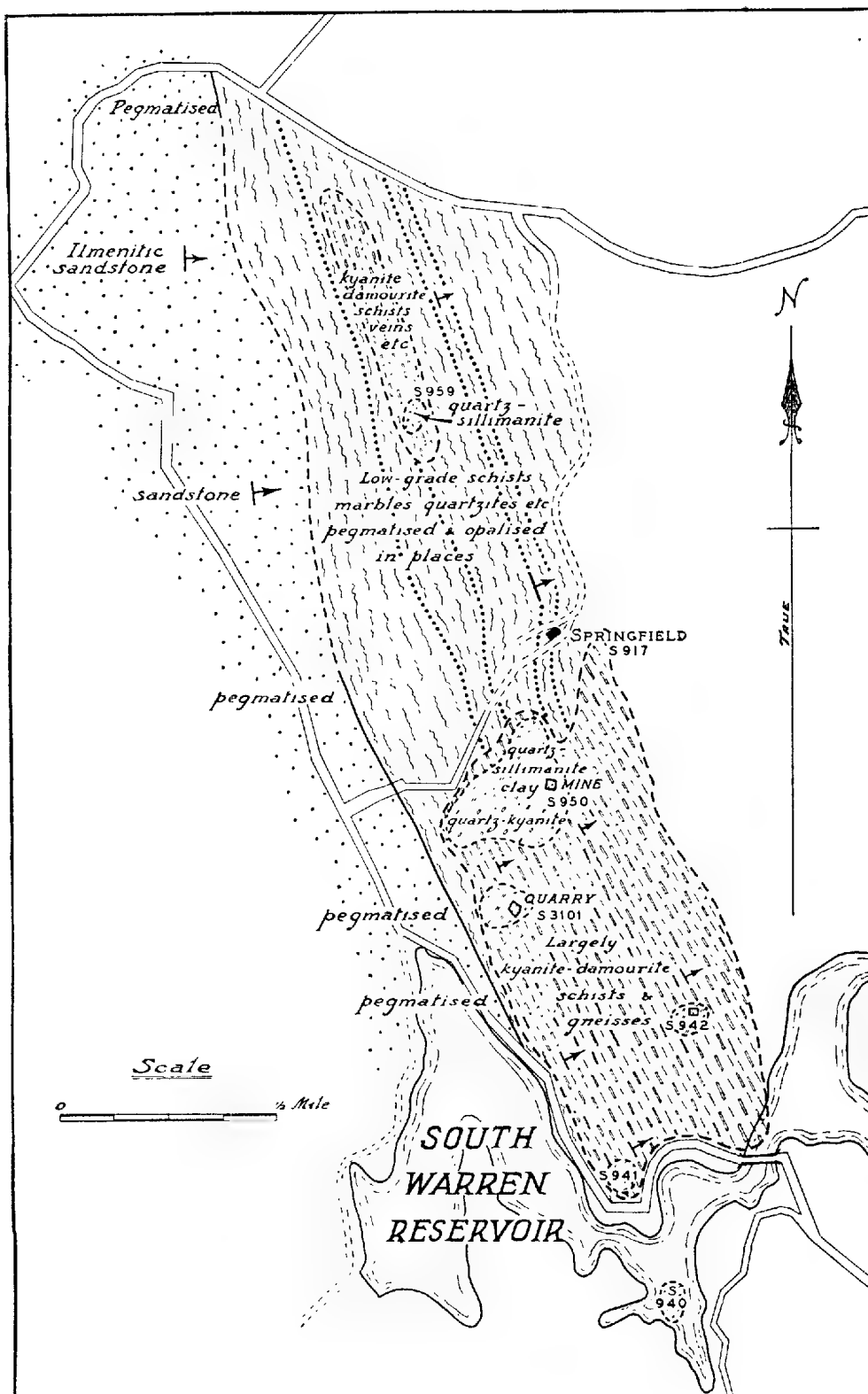
#### OCCURRENCE

The accompanying map shows that the western part of the area is occupied by a considerable thickness of sandstones or grits which are generally regarded as the basal members of part of the Proterozoic Adelaide Series (Howchin, 1926; Hossfeld, 1935). The bedding of these rocks is well shown by the presence of much detrital iron-ore which is usually referred to as ilmenite, although titaniferous magnetite is probably a better description. Along their eastern margin these beds are in places highly pegmatized, and although they show a good deal of drag-folding the general dip is steep and to the east. With minor variations, the rocks of the whole of the area shown in the map have an average strike of about  $30^{\circ}$  W. of N. and dip steeply towards the east.

The rocks overlying the ilmenitic sandstones are best observed to the north and west of Springfield House, where the degree of metamorphism is not so great. As has already been mentioned, Hossfeld considers that the sequence here is inverted and that the rocks to the east of the ilmenitic sandstones are actually older and are of Barossian age. These, which for convenience will be referred to in this paper as low-grade schists, are metamorphosed sediments and consist of a series of schists, flagstones, marbles, quartzites, and sandstones, although around and to the north of Section 959 the metamorphism is much greater and a narrow belt of sillimanite-clay and kyanite-damourite rocks occur.

To the south of Springfield House the low-grade schists are also replaced by a large area of rocks in which sillimanite and kyanite and their derivatives, clay and damourite, are the dominant features. It will be seen from the map that these aluminous rocks cut directly across the bedding of the low-grade rocks, which occur to the north. The general trend of the kyanite-damourite schists and gneisses is also truncated by the quartz-kyanite and quartz-sillimanite rocks and their derived clays. Where the quartz-sillimanite rocks show a rough banding, and this is confined to the quartz-rich members of the group, this banding is parallel to the foliation of the schists and gneisses which lie to the south and also to the bedding of the low-grade schists which occur in the north.

The relations of the aluminous rocks in the field and also their mineralogical and petrological characters indicate that they have been very largely formed by replacement and are the metasomatized representatives of the low-grade schists which occur in the northern part of the area. Although folding and faulting are shown around the margins of the aluminous rocks, these appear to be on a small scale and are probably due to volume changes accompanying the metasomatic processes. There does not seem to be any major structural feature separating the aluminous rocks from the low-grade rocks.



## GENESIS

The suggestion that the main masses of these aluminous rocks have been formed by metasomatic processes has already been made in this paper. A somewhat similar explanation has been made to account for the occurrence of kyanite in North Carolina, where kyanite occurs as disseminated crystals in schists and other rocks, as well as in quartz veins and pegmatites. As shown by J. I. Stuckey (1932), the kyanite has probably been formed as a replacement of older minerals through the activity of pegmatitic solutions. In the Williamstown district the more usual modes of origin of sillimanite and kyanite seem to be inadmissible for many reasons. The extraordinary purity of the quartz-sillimanite and quartz-kyanite rocks, in which rutile is frequently the only other mineral present, seems to preclude their derivation from bedded aluminous sediments. Advancing regional metamorphism in its highest grade might account for the occurrence of sillimanite and kyanite together; but in the Williamstown occurrence the metamorphism is extraordinarily localised and the neighbouring rocks have reached merely a low grade; moreover, the aluminous rocks are not confined to one stratigraphic horizon, but replace rocks of such varying compositions as dolomitic marbles, quartzites, and pelites. It might be argued that they are metamorphosed bauxitic clays formed on an ancient land-surface, a theory which Dunn (1929) has advanced to account for somewhat similar deposits in Singhbhum, but the localised character of the metamorphism, as well as the texture of the rocks themselves, makes this theory unacceptable.

The circumstances of occurrence of corundum-sillimanite rock in the norite of the Bushveldt complex as described by Hall and Nel (1926), and of kyanite in the marundites and allied rocks in the Eastern Transvaal, also described by Hall (1923), are so different from those at present under discussion that they can be neglected.

A theory suggesting the metasomatic origin of kyanite and sillimanite rocks pre-supposes the existence of fluids very rich in alumina. That such fluids, in some form or other, existed in the Williamstown area is proved by the widespread occurrence of quartz-kyanite veins and also of kyanite-pegmatites. Although the smaller of the quartz-kyanite veins, and particularly those occurring in massive quartz-sillimanite rock, may be segregation veins formed by the migration of aluminium silicate under changed physical conditions, this is a most unlikely explanation for the formation of the larger veins and pegmatites.

Magmatic fluids sufficiently rich in alumina to produce the crystallisation of aluminium silicates are usually supposed to owe their origin to contamination by rocks of sedimentary origin. However, this supposition does not seem to be necessary, and there is certainly no positive evidence for it in the Williamstown area. E. S. Hills (1938) has reviewed the evidences which show that andalusite and sillimanite may sometimes occur in uncontaminated igneous rocks. In this paper Hills shows that andalusite occurring in such a way is far commoner than sillimanite, but he comes to the conclusion that there is good evidence to show that solutions rich in alumina can be developed from magmas without the aid of contamination. In papers, also quoted by Hills, H. H. Read (1931) from his study of sillimanite-bearing granites in the Strath Halladale injection complex has seen the possibility of alumina-rich liquids constituting the residual portions of granite magma, and P. Niggli (1920) has suggested that the alumina in such liquids may be present as aluminium halides, alkali aluminate and similar compounds. In a later paper, Niggli (1925) concludes that under special circumstance normal magmas may give rise to sillimanite and andalusite.

In California Macdonald and Merriam (1938) have described the occurrence in Fresno County of andalusite developed by pneumatolytic action in pegmatite. In a neighbouring locality, near Kings River, Durrell and Macdonald (1939) have

indicated that chlorite veins occurring in serpentine are the result of the introduction of alumina from igneous emanations. In these two instances the activity of alumina-rich fluids seems to be undoubted, and it is suggested that they are derived from neighbouring diorite intrusions.

In the past, aluminium-metasomatism has not been considered by many writers to be an important factor in petrogenesis. Goldschmidt (1922), in a discussion of the general nature of metasomatic processes in silicate rocks, gives instances of metasomatism in which all the common metals except aluminium are introduced. Many writers, including Goldschmidt (1911), suggest that some metals, particularly iron, may be introduced in the form of chlorides and other halides. This is particularly interesting in view of Niggli's suggestion, mentioned above, that alumina-rich solutions concentrated from magmas may have the alumina present in the form of halides. C. N. Fenner (1933, p. 54) comments on the high volatility of  $\text{FeCl}_3$  and  $\text{AlCl}_3$ , as shown by figures obtained by C. G. Maier (1925).  $\text{FeCl}_3$  at a temperature of  $318.4^\circ\text{C}$ . has a vapour pressure equivalent to 872.6 mm. of mercury. The corresponding figures for  $\text{AlCl}_3$  are  $181.3^\circ\text{C}$ . and 960.1 mm. of mercury. These vapour pressures are among the highest of all the common metals, and Fenner points out that because of this and because of the mass action effect caused by their large concentration in a magma they might be expected to be volatilised in the greatest quantities. However, in the case of  $\text{AlCl}_3$  its tendency to react with water to form oxide exerts a restraining influence, which may prevent Al from being carried far, or may diminish to a great degree its escape from the magma, *unless the ratio of HCl to water vapour is unusually high*. In another part of the same paper (p. 77) Fenner points out that hydrochloric acid is sometimes present in very large amounts during magmatic activity and quotes the work of Zies (1929), who calculated that in 1919 the fumaroles of the Valley of Ten Thousand Smokes, in the Katmai region, were evolving hydrochloric acid at the rate of about 1,250,000 tons per year, and hydrofluoric acid about 200,000 tons. This was seven years after the initial outbursts in the Katmai region, when presumably the evolution of gas had been even greater. These considerations suggest that under special, and perhaps rather rare, conditions aluminium-rich liquids may be sufficiently concentrated, mobile and active to promote metasomatic processes. I believe that such a combination of circumstances produced the aluminous rocks of the Williamstown area. The rarity of similar examples of aluminium metasomatism would be due to (a) the rarity of solutions containing a sufficient aluminium content to cause metasomatic replacement, and (b) the non-mobility of most of such alumina-rich solutions.

#### HISTORY AND CORRELATION

My conclusions concerning the history of the Williamstown deposits can best be summed up by considering them to have originated in a number of periods or phases. Although these phases will be considered separately and in sequence it must be understood that there would have been a transition between phases and between localities, and that the phases may overlap in time from one locality to another. The controlling factors would appear to be falling temperature and falling alumina-concentration, with changes in pressure exerting no great effect.

1. *Sillimanite Phase*—This is the period of maximum intensity of aluminium-metasomatism, during which there was an introduction of alumina, silica and probably titania. The purer sillimanite deposits and the quartz-sillimanite-rutile rocks would have been formed by this action. Rutile, in small amounts, is a common constituent of these rocks, and it is probable that most of the titania was introduced, although some may be derived from the original sediments, many of which contain original rutile. With this possible exception and perhaps some silica, all the varied components of the sediments have been replaced. The areas

of sillimanite-quartz rocks are regarded as centres at which metasomatic activity was greatest.

2. *Quartz-kyanite-rock Phase*—The reaction would be essentially the same as those in Phase 1, with kyanite formed instead of sillimanite. The quartz-kyanite rocks form a partial margin to, and merge into, the quartz-sillimanite rocks. This phase is thus intermediate in all respects between Phases 1 and 3.

3. *Main Kyanite Phase*—The effects are very widespread and can be subdivided:

- (a) Kyanite veins and segregations in the sillimanite rocks were obviously formed after solidification of the sillimanite. The smaller ones have probably developed through localised migration of aluminium silicate derived from the host-rock under changed physical conditions, and thus be somewhat similar in origin to the quartz-kyanite venules described by C. E. Tilley (1937) in some kyanite-amphibolites. Such a mode of origin, although applicable to small individuals, seems very unlikely for the larger kyanite veins, and it would appear that these were formed from the aluminium-rich solutions which produced the sillimanite but at a lower temperature and probably lower aluminium concentration.
- (b) The kyanite(-damourite)-schists and gneisses testify to the changed composition or lower temperature of aluminous solutions, which can be pictured as permeating outwards from the centres of greatest activity developed in Phase 1. The extent to which materials other than silica and alumina have migrated during the reactions is problematical.
- (c) Large veins and masses of kyanite (now largely damourite) with or without quartz occur in a number of localities in the kyanite-damourite-schists. The quartz-free occurrences sometimes show the presence of corundum. Although rutile occurs as disseminations in the majority of rocks formed in Phases 1, 2, and 3, it reaches its greatest development in some of the kyanite-damourite veins, thus indicating the maximum activity of titanium during the sequence. Some of the more quartzose veins have a small amount of orthoclase feldspar, and thus form a natural transition to Phase 4.

4. *Kyanite-pegmatite Phase*—With falling temperature, the increasing importance of alkali is shown by the kyanite-orthoclase-pegmatite phase. The presence of kyanite indicates that the solutions are still rich in aluminium. There is no direct proof that these rocks were formed at this stage of the sequence; however, they fit best into the general scheme here.

5. *Normal Pegmatite Phase*—Quartz-orthoclase-muscovite-pegmatites are a common feature of the area and extend beyond the limits of the aluminous rocks. Tourmaline and beryl are common components with rutile a good deal scarcer. The presence of orthoclase and muscovite and the absence of kyanite show that the proportion of alkalis has increased with respect to alumina. Tourmaline is not present in significant amounts in unaltered rocks of the earlier phases, so that its occurrence in these pegmatites is notable and indicates the activity of boron. The scarcity of rutile shows that titanium is no longer important in the solutions.

6. *Hydrothermal Phase*—The main features of this phase are the conversion of sillimanite to clay and of kyanite to damourite. This latter reaction requires the presence of alkalis, so that potash, particularly, must have been active through at least part of this phase. Boron is still notable, tourmaline being fairly common in both clay and damourite while being insignificant or absent from the unaltered sillimanite and kyanite rocks. This point is of some importance as it indicates that the activity of boron was confined to the later phases. A comparison of analyses of sillimanite and clay (table A) shows that silica was added during the conversion. It has already been noted that the change of sillimanite to clay was

not a complete one, and that the clay normally contains fine needles of sillimanite.

The clay described here is the northern limit of a belt of clay deposits which extend for some miles roughly in a south-south-east direction as far as Birdwood. In the Williamstown area the clay rocks coincide very approximately with the quartz-sillimanite rocks, although pegmatites and other rock-types have also suffered kaolinisation. As the quartz-sillimanite rocks seem to be confined to the Williamstown area, it would appear that the metasomatism reached its greatest activity in the northern part of the belt, while further south the pegmatite and hydrothermal phases were the main manifestations.

Table C summarises the nature of the substances active during the various phases.

**TABLE C.**

ACTIVE SUBSTANCES	PHASES				
	1 SILLIMANITE	2 & 3 KYANITE ROCKS	4 KYANITE PEGMATITES	5 PEGMATITES	6 HYDROTHERMAL
SiO <sub>2</sub>	—————	—————	—————	—————	—————
Al	—————	—————	—————	—————	—————
Ti	—————	—————	—————	—————	—————
K (Na)		—————	—————	—————	—————
B			—————	—————	—————
OH				—————	—————
TEMP.	HIGH	—————	—————	—————	LOW

The association of rutile with sillimanite and kyanite rocks is very striking in this area. It is notable that the same association is shown in other places where aluminium silicate minerals occur. It is possible that the similar ionic radii of aluminium and titanium, 1.43 and 1.46 A.U., respectively, may be responsible for the occurrence together of these minerals. In his memoir on the aluminous refractory minerals of Northern India, Dunn (1929), records the almost invariable association of rutile with sillimanite and kyanite. There are many other similarities between these occurrences in India and that at Williamstown. However, Dunn has maintained that the Indian deposits have been formed by the metamorphism of bauxitic clays, an explanation which is untenable for those at Williamstown. In the Bhandara district, kyanite and sillimanite rocks are accompanied by such minerals as rutile, tourmaline, dumortierite, topaz, and roscoelite. S. K. Chatterjee (1931) has suggested that, accompanying the intrusion of tourmaline-muscovite-pegmatites, boron containing liquids would form mobile solutions of aluminium silicate by reaction with the surrounding chlorite-muscovite-schists, and that the kyanite and sillimanite rocks were derived from these liquids. Such an explanation could not apply to the Williamstown rocks, because boron does not appear to have been active until a late stage in the metasomatic processes, in fact, till after the sillimanite and kyanite rocks were formed.

Large masses of andalusite occur at White Mountain and elsewhere in California. According to P. F. Kerr (1932) these owe their origin to the metamorphism of aluminous rocks (probably trachytic lavas) by porphyry intrusions. Rutile was introduced during the metamorphism and topaz and tourmaline during a subsequent pneumatolytic stage. The association of rutile with an aluminium silicate mineral is again notable. This extremely common association has been commented on by J. A. Dunn (1933) who insists that the rutile, as well as the aluminium silicate mineral, is never of magmatic origin but is derived from meta-



morphosed country rock. Certainly much of the country rock at Williamstown has a titanium content which cannot be disregarded, but this could certainly not account for the richness in rutile of the great bulk of the aluminium-silicate-rocks in that area, where the amounts of titanium and aluminium seem to be roughly proportional. The country rocks richest in titanium are felspathic sandstones. Strangely enough, rutile is apparently a negligible component of the kyanite rocks of North Carolina, which, according to Stuckey (1932) have had an origin very similar to those at Williamstown. With this exception rutile and tourmaline and frequently topaz and dumortierite are very usual associates of the aluminium silicate minerals. So far neither topaz nor dumortierite have been identified in the Williamstown area, where it is possible they have been overlooked.

#### SUMMARY

Massive quartz-sillimanite and quartz-kyanite rocks associated with kyanite-schists, quartz-kyanite-veins and kyanite-pegmatites occur in a region of low-grade metamorphosed sediments which have also been intruded by normal pegmatites. Sillimanite has been largely converted to clay (probably dickite) and kyanite to danburite. Rutile is a very constant associate of the aluminium silicate minerals. Aluminium-rich solutions of magmatic origin are believed to have produced varying degrees of metasomatism in the country rock, after which pegmatitic and hydrothermal phases were active.

I wish to express my indebtedness to Sir Douglas Mawson, Prof. C. E. Tilley, Mr. R. Grenfell Thomas and Dr. A. B. Edwards, to whom I have discussed this work in the field or in the laboratory. Mr. W. B. Dallwitz has made several chemical and mineralogical determinations. Mr. H. E. Brock prepared the map and several of the diagrams for reproduction. Finally, I must thank Mr. G. Warren for his interest and kindness at Springfield.

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# THE ANYSTID MITES OF AUSTRALIA

By H. WOMERSLEY, A.L.S., F.R.E.S., South Australian Museum

## Summary

Family ANYSTIDAE Oudemans, 1902

Reddish to yellowish, soft-bodied, long-legged, free-living predaceous mites. Body short and broad, and somewhat triangular (subfamily Anystinae) or elongate-elliptical (subfamily Erythracarinae). Cuticle soft and finely striated. Eyes, one or two on each side, generally strongly pigmented. No transverse suture between propodo- and hysterosoma. Palpi 5-segmented; tibia with a series of stout apical spines; tarsus situated ventrally, long and slender. Mandibles clubshaped with hook-like apical chela. Peritremata horn-like arising from the base of the mandibles; arms free or not. Dorsally usually with an anterior median shield formed by absence of cuticular striations, or by striations running in a different direction; sometimes absent. Dorsal setae long, thick and coarsely, strongly ciliated, frequently on small islands or plates of non-striated cuticle; in transverse rows of 2, 4, or 6. In front of the propodosoma is a hemispherical projection (anterior sensillary area of crista of Oudemans) bearing a pair of fine sensory setae. The dorsal shield carries a second pair of sensory setae and two pairs of normal setae.

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Legs long and slender with long ciliated, and some sensory, setae; tarsi with paired claws (ciliated) and a more or less bell-shaped empodium, or claws toothed on inner margins, empodium claw-like or as a ciliated pad-like pulvillus. Tarsi sometimes subdivided. Coxae in four pairs or all adjacent.

Ventrally are the large genital and anal openings, with or without a small round plate anterior of the genital opening. The setae around the genital and anal opening are of generic importance, often being arranged on small plates, either singly or in twos.

Little is known of the life-history beyond the larvae and nymphs of some species of *Anystinae*.

The family is divided by Oudemans into two well-defined subfamilies, the *Anystinae* and the *Erythracarinae*.

## ANYSTINAE Oudemans 1906

Arch. f. Naturgesch., 5, (3), 383, 1936.

Short and broad; two eyes on each side, situated comparatively well behind. Anterior sensillary area and paired sensillae present. Median dorsal shield wider than long with paired antero-median sensillae and four normal setae. Peritremata horn-like with free ends. Palpi: tibia with three stout apical spines (one on larva), tarsus long. Dorsal setae in rows of four often arising from small areas (? shields) devoid of striations, long, strong and coarsely ciliated. Coxae all adjacent, I and II with supracoxal seta. Upper surface of legs smooth; the free segments with sparse sensory setae, short, smooth, adpressed setae and long ciliated outstanding setae. Basi- and telofemur always separated. Tibia longer than tarsi and considerably thinner than genu; tarsi short, somewhat laterally compressed, often arched. Claws smooth, finely striated. Empodium in larvae claw-like, twice bent; in nymph I claw-like only on leg IV, on leg I to III bell-shaped; in all other instars and on all legs bell-shaped.

Ventrally; labium with 8-12 pairs of fine setae. Between coxae III and IV a median round shield. On each side of the genital opening two very small shields, with a single long or special setae, or on each side only one shield with two setae. Also on each side of uropore three or four very small shields with single setae.

The male is characterised by conical distally clavate setae on the palpal tarsi and by the ciliated anal setae.

#### KEY TO THE GENERA OF ANYSTINAE

- 1 Without a median dorsal shield. In the position of the shield with 2 sensory setae and 4 normal setae. Dorsal setae 4, 6, 6, 4, 2. Small shields near genital opening with only a single seta. 2  
Gen. *Teneatcia* Ouds. 1936  
 With a median dorsal shield.
- 2 Median shield with entire transverse striations, with 2 sensory and 4 normal setae. Dorsal setae 4, 4, 4. Small shields near genital opening with only a single seta. 3  
Gen. *Walsia* Ouds. 1936  
 Median shield with short transverse striations along the midline, otherwise as above. 3  
Gen. *Snartia* Ouds. 1936  
 Median dorsal shield entirely without striations or with finely punctured reticulations.
- 3 Small shields near genital opening with only single setae. Median dorsal shield more than twice as wide as long. 3  
Gen. *Anystis* von Heyden 1826  
 Small shields near genital opening with paired setae. Median dorsal shield relatively not so wide as long.  
Gen. *Scharfenbergia* Ouds. 1936

N.B.—Oudemans (1936) also erects the genus *Autenriethia* for *Actineda velox* Berl. 1905 from India, and *Barellea* for *Anystis sinensis* Berl. 1923 from China. The data given, however, does not permit them to be keyed here.

#### Genus ANYSTIS von Heyden 1826

##### ANYSTIS BACCARUM (Linn. 1758)

In his monographic revision of the family Anystidae (Arch. f. Naturgesch., 1936, Bd. 5, Hft. 3, 364-346) Oudemans questions my record of this species from Western Australia, Victoria, New South Wales and South Australia (Trans. Roy. Soc. S. Aust., 1933, 57, 111). I must admit that at that time one did not recognise the minute details now used by Oudemans for the separation of genera and species of this family. In consequence, in working up new material I have taken the opportunity to re-examine my older mounts more critically. The result is that I can now affirm that all my old records are definitely of *A. baccarum* as understood by Oudemans. From this material I herewith give sufficient figured details to show that this is so.

Unfortunately, however, Oudemans does not satisfactorily point out the specific differences in the species of *Anystis* nor does he key the species. While some of his species are valid, others seem to be very little if at all different from *baccarum*.

He does not describe the male of this species, but of the genus states that the males are distinguished by the conical distally clavate setae on the dorsal side of the palpi, and mostly by the ciliated setae in the neighbourhood of the genital opening. I give, therefore, a figure of the genital and anal openings, in which it will be seen that the ciliated setae are associated with the anal and not the genital opening (fig. D).

The following dimensions are from a male and a female specimen, respectively, from Buckland Park, South Australia. The female was gravid.

Length ♂ 990  $\mu$ , ♀ 910  $\mu$ ; width 1,040  $\mu$ , 1,083  $\mu$ . Length of palpi 400  $\mu$ , 480  $\mu$ . Length of mandibles 290  $\mu$ , 290  $\mu$ . Anterior sensillary setae 113  $\mu$ , 121  $\mu$ . Posterior sensillary setae 135  $\mu$ , 148  $\mu$ . Scutal setae 243  $\mu$ , 243  $\mu$ . Dorsal setae 240  $\mu$ , 240  $\mu$ . Width of median dorsal scutum 370  $\mu$ , 370  $\mu$ ; depth 103  $\mu$ , 103  $\mu$ . Legs I 1,120  $\mu$ , 1,040  $\mu$ ; II 1,520  $\mu$ , 1,120  $\mu$ ; III 1,390  $\mu$ , 1,040  $\mu$ ; IV 1,120  $\mu$ , 1,040  $\mu$ . Tarsus  $1\frac{2}{3}$  length of metatarsus in both sexes.

*Localities*—Western Australia: Waroona, August 1931; Mullewa, September 1931. New South Wales: Five Islands, July 1938. Victoria: Dan-

denongs, 1931; Burnley, 1938. South Australia: Urrbrae, May 1930; Buckland Park, August 1933; Waterfall Gully, May 1938; Humbug Scrub, October 1938; Bridgewater, February 1939; Victor Harbour, May 1939.

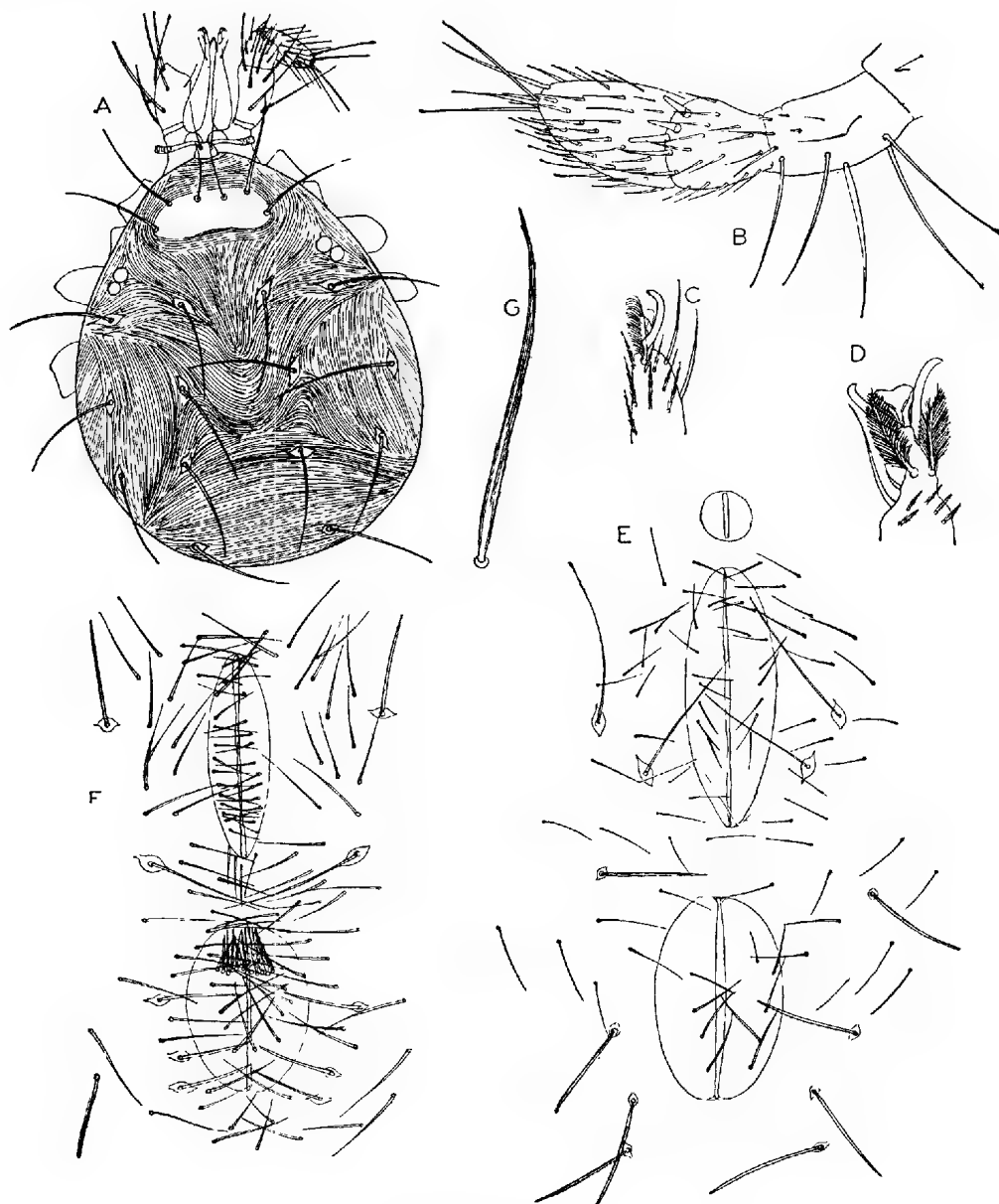


Fig. 1 A—F

*Anystis baccharum* (L.)—A, dorsal view of ♀; B, palp of ♂; C, tip of tarsus from side; D, same from below; E, genital and anal opening of ♀; F, same of ♂.

Gen. WALZIA Oudemans 1936

Arch. f. Naturgesch., 5, (3), 419.

As in *Anystis*, but the position of the median dorsal shield with fine horizontal striations. Type species, *W. antiguensis* (Stoll. 1886) Ouds., 1936.

**Walzia australica** n. sp

*Description*.—*Female*: Length 880  $\mu$ , width 800  $\mu$ , when gravid 720  $\mu$  long by 850  $\mu$  wide. Palpi as figured 380  $\mu$  long, apex of tibia with three long and one small, stout spines. Mandibles 230  $\mu$  long. Median dorsal scute 310  $\mu$  wide, 108  $\mu$  long, with horizontal fine striations, with a median pair of sensory setae and two pairs of normal setae. Anterior sensory setae 108  $\mu$  long, posterior 135  $\mu$ , ciliated for about the distal three-fourths. Dorsal setae on small plates, 216  $\mu$  long, ciliated, arranged 4, 4, 4, 4. Legs I 1,280  $\mu$ , II 1,360  $\mu$ , III 1,200  $\mu$ , IV 1,300  $\mu$ ; tarsus I 216  $\mu$ , metatarsus I 304  $\mu$ ; with numerous adpressed setae, and long outstanding ciliated setae; claws and empodium as figured. Venter: Genital and anal openings as figured. *Male*: Length 640  $\mu$ , width 590  $\mu$ . Palpi as figured,

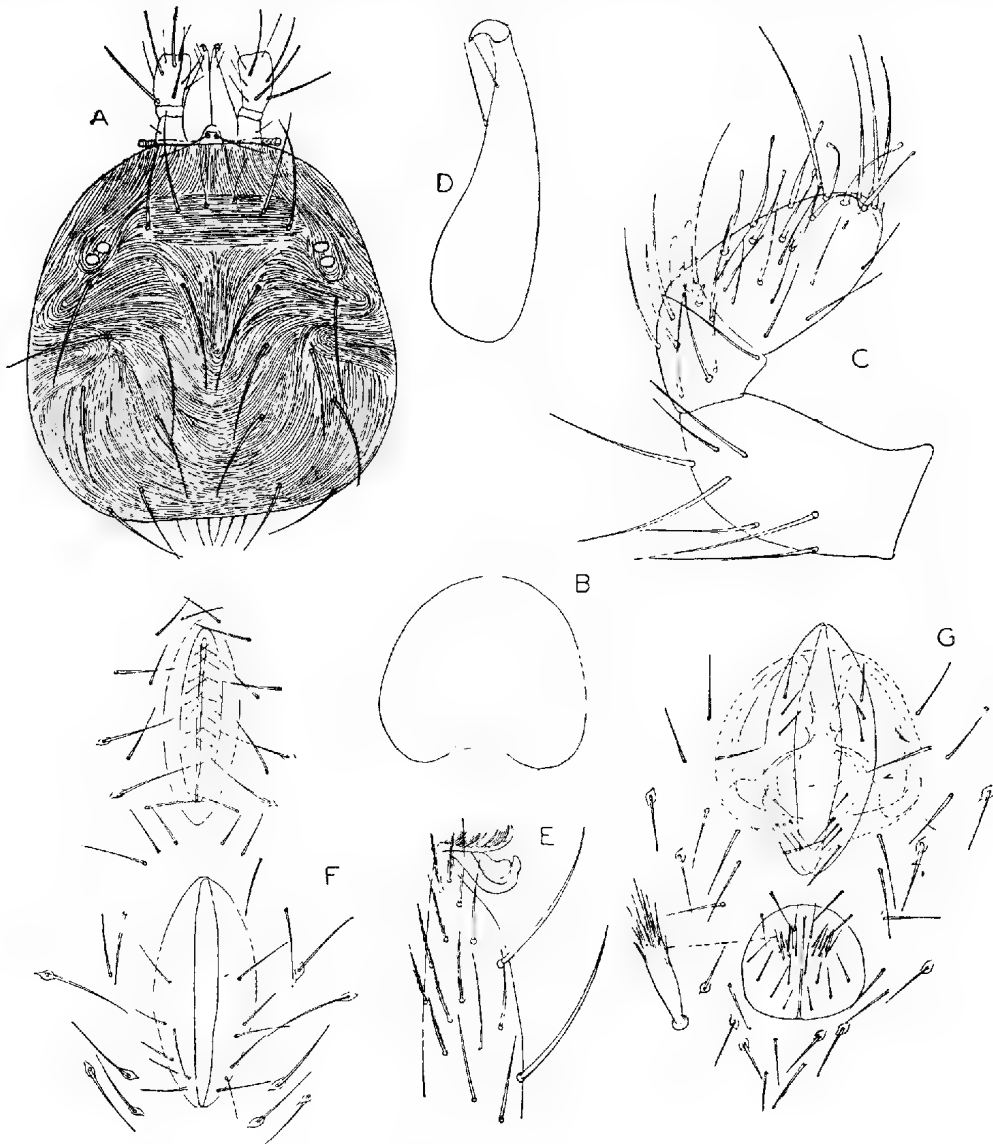


Fig. 2 A—G

**Walzia australica** n. sp.—A, dorsal view of ♀; B, outline of gravid ♀; C, palp of ♂; D, mandible; E, tip of tarsus from side; F, genital and anal openings of ♀; G, same of ♂.

with dorsally numerous conical and apically clavate setae. Mandibles  $220\ \mu$  long. Median dorsal scute as in female  $324\ \mu$  wide by  $120\ \mu$  long; scutal setae  $243\ \mu$ . Anterior sensory setae  $108\ \mu$ , posterior  $121\ \mu$ . Legs I  $960\ \mu$ , II  $1,040\ \mu$ , III  $880\ \mu$ , IV  $930\ \mu$ ; tarsus I  $150\ \mu$ , metatarsus I  $255\ \mu$ . Dorsal setae on small plates as in female. Venter: Genital and anal openings as figured; anal opening anteriorly with a cluster of specialised setae.

*Localities*—South Australia: Port McDonnell, January 1941, four  $\delta$ , two  $\varphi$ , on ti-tree (J. S. W.). Queensland: Nurimbah, April 1935,  $\varphi$  (A. R. B.); Mount Cotton, Brisbane, on *Jacksonia*, 3 September 1941, two  $\varphi$ ; Redland Bay, on *Leptospermum*, 3 September 1941, one  $\delta$ , one  $\varphi$  (A. R. B.).

*Remarks*—This species may possibly be identical with the genotype *Walzia antiquensis* (Stoll, 1886), but it seems advisable at present, on account of the localities, to regard it as distinct. There are, however, no essential specific differences observable.

#### Subfamily ERYTHRACARINAE Oudemans 1936

Archiv. f. Naturgesch., 5, (3), 427, 1936.

Mostly elongate, two or four eyes situated well forward. Peritremata mostly fused with the front edge of the epistoma. On the front of the idiosoma with or without a sensillary area, with two sensillary setae; behind these again a second pair of sensillary setae, which, if a median dorsal shield is present, are situated thereon. Median dorsal shield present or absent. Dorsal setae behind shield in transverse rows of 2, 4 or 6. Mandibles short, longitudinally striate.

Palpal tibia with two ciliated claws, or only one smooth claw. Legs with short adpressed and long outstanding setae, both ciliated, in addition to some sparse sensory setae. Tibiae in the 2-eyed genera longer, in the 4-eyed shorter than the tarsi. Tarsi cylindrical, undivided or divided into two or many parts. Empodium claw- or brush-like. Coxae conjoined or free. No small shield between coxae III and IV. Near genital and anal openings no setae on small plates. Male with specialised setae in a cluster associated with anal opening. Uropore terminal.

The subfamily is divided by Oudemans (*loc. cit.*, 428) into the following groups of genera:

Group A Scapula row of setae with 4, the other rows with only 2. Peritremata not chambered. Anterior sensillary area present. Palpi long and slender, femur and genu fused. Empodium a short thick, ciliated claw.

Genera *Erythracarus*, *Schellenbergia*, *Bechstaenia*

Group B Dorsal setae in transverse row of 4 or more. Peritremata chambered, built into the front edge of epistoma, their ends not free. No anterior sensillary area. Mandible with two setae, posterior needle-like and outstanding. Palpi short and thick, femur and genu separated. Basi- and telofemur of legs separated; their setae forming a crown. Tarsi subdivided into from 7 to 18 parts. All four pairs of coxae separated; their posterior margins indistinct.

Genera *Tarsotomus*, *Tarsolarkus*

Group C Dorsum strongly haired. Propodosoma with large round shield, which is only haired on the edge. No anterior sensillary area. Two eyes on each side. Palpi short and thick. Basi- and telofemur of legs with crown of setae. Coxal pairs touching.

Genus *Anandia*

Group D Short, rounded, quite quadrangular. Gnathosoma very short. Palpi short.

Genus *Siblyia*

Group E Only two eyes. Palpal tibia with only one claw.

Genus *Chabrieria*

As yet only the genera *Erythracarus* Berl. 1903, and *Schellenbergia* Ouds. 1936, are known from Australia.



## Genus SCHELLENBERGIA Oudemans 1936

Archiv. f. Naturgesch., 5, (3), 433, 1936.

One eye on each side. Median dorsal shield broader than long. Dorsal setae on small shields. Peritremata  $\hookleftarrow$ -shaped; distally broadened and the ends free. Anterior sensory area present, with terminal knob. Mandibles with two setae. All legs with basi- and telofemur ankylosed. Tarsus shorter than tibia with long basal part and short distal part. All coxae adjacent.

Type *Erythraeus domesticus* C. L. Koch 1847

**Schellenbergia warregense** (Hirst 1931) n. comb.

P.Z.S., 562, as *Tarsotomus warregense*; Oudemans. 1936 (*loc. cit.*), 442.

Oudemans (*loc. cit.*) places this species amongst a list of uncertain and inadequately described species of *Tarsotomus*. He queries Hirst's reference to the sexes, in which the female is said to have a comb of specialised setae around the genital opening. Oudemans correctly considers that this sex is the male.

As the type material of this species has been deposited by Prof. T. Harvey Johnston in the South Australian Museum, it is now possible to place the species in Oudemans's new genus *Schellenbergia*. As Hirst's paper was published posthumously after an unsuccessful search for his drawings, detailed figures drawn from the type material are now given together with a more detailed and adequate description.

*Description*—*Male*: Length ca. 1,120  $\mu$ , width ca. 720  $\mu$ ; elongate. Eyes 1 + 1. Dorsal scute large, wider than long, approximately 310  $\mu$  by 162  $\mu$ ; outline approximately as in figure. Anterior sensillary area present, with anterior knob and a pair of sensory setae 190  $\mu$  long. Posterior sensory setae missing. Palpi 480  $\mu$  long, tibiae with two unequal shortly and coarsely ciliated claws at apex, tarsi long. Mandibles 160  $\mu$  long, with a short simple subapical seta, and a long straight outstanding ciliated posterior seta. Scutal setae 216  $\mu$ . Dorsal setae 220  $\mu$ , arranged 4, 2, 2, plus. Legs I 1,200  $\mu$ , II 1,320  $\mu$ , III 1,120  $\mu$ , IV 1,680  $\mu$ ; tarsus I subdivided into basitarsus 216  $\mu$  long and telotarsus 81  $\mu$ ; metatarsus I 300  $\mu$ . Genital opening with a complicated brush of specialised ciliated setae as figured. Dorsal setae strongly and coarsely ciliated as are the leg setae, especially the outstanding ones. Claws and empodium as figured. *Female*: Length 800  $\mu$ , width 560  $\mu$ . Dorsal scute 320  $\mu$  wide by 128  $\mu$  long. Dorsal setae to 240  $\mu$ . Sensory setae, both anterior and posterior, missing. Genital opening as figured. Otherwise as in male.

*Locality*—The type material in the South Australian Museum consists of one  $\sigma$ , two  $\text{f}$  from Barrington, New South Wales, August 1927 (coll. S. Hirst) and one  $\text{f}$  from Bourke, New South Wales, August 1927 (coll. S. Hirst). The  $\sigma$  is the holotype, and the  $\text{f}$  from Bourke the allotype.

## Genus ERYTHRACARUS Berl. 1903

Eyes 2 + 2. Median dorsal shield longer than wide. Dorsal setae on small shields. Peritremata quite straight; their ends free. Anterior sensillary area with ventral point. Mandible with a distal seta only. Basi- and telofemur of all legs dorsally ankylosed. Tarsi longer than tibiae and not subdivided. All coxal pairs adjacent. Genital opening of male with clavate setae.

Type *Trombidium parietinum* Herm. 1804

## ERYTHRACARUS ? PARIETINUM (Herm. 1804)

*Trombidium parietinum* Herm. 1804.

*Erythracarus parietinum* Ouds. 1936. Archiv. f. Naturgesch., 5, (3), 429.

A single specimen from under *Eucalyptus* bark, Bathurst, New South Wales, 30 December 1937 (S. L. A.).

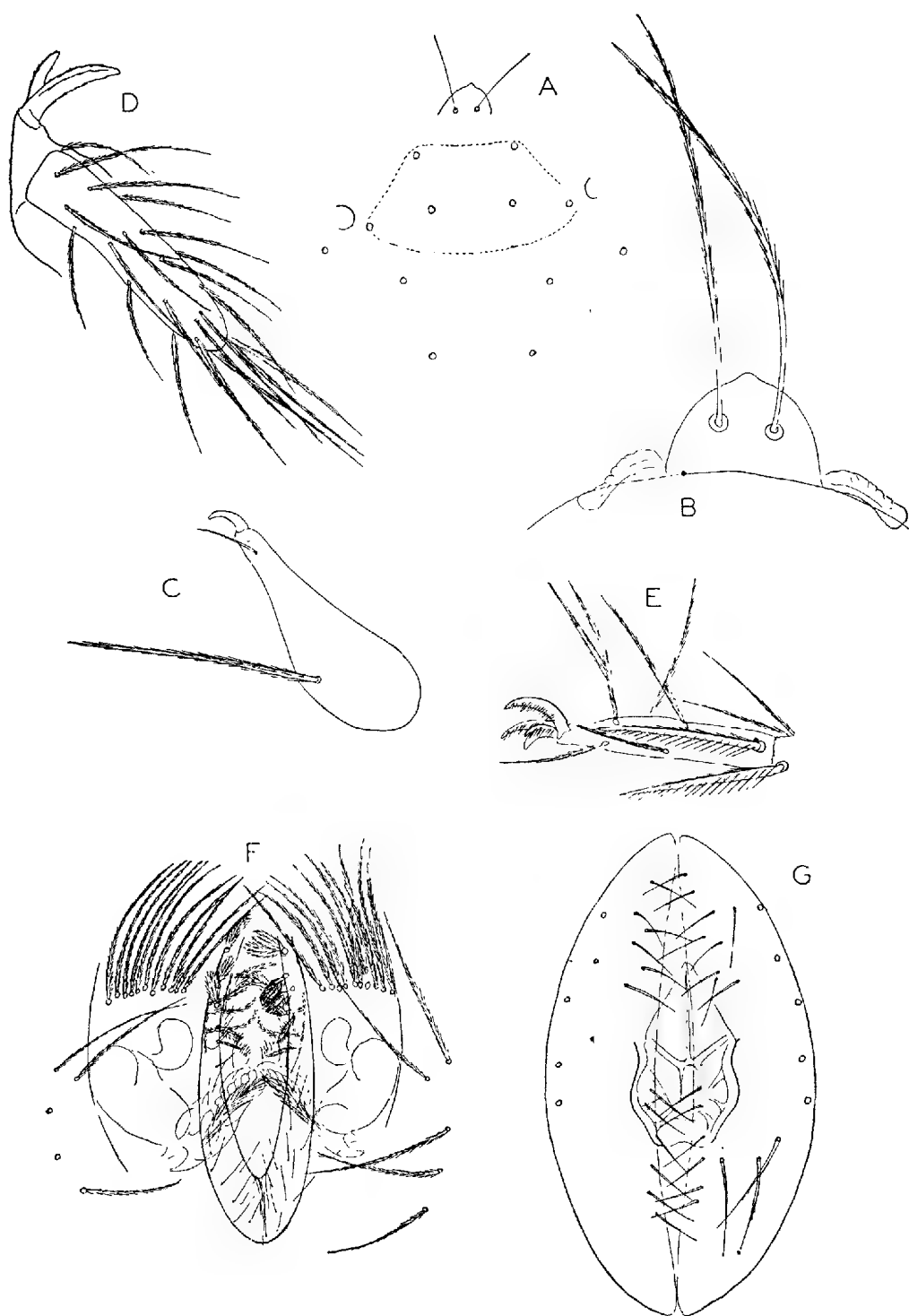


Fig. 3 A-G

*Schellenbergia warregense* (Hirst)—A, anterior portion of dorsum; B, anterior sensillary area and peritremata; C, mandible; D, tip of palpal tibia and tarsus; E, tarsus of leg II; F, genital opening of ♂; G, same of ♀.

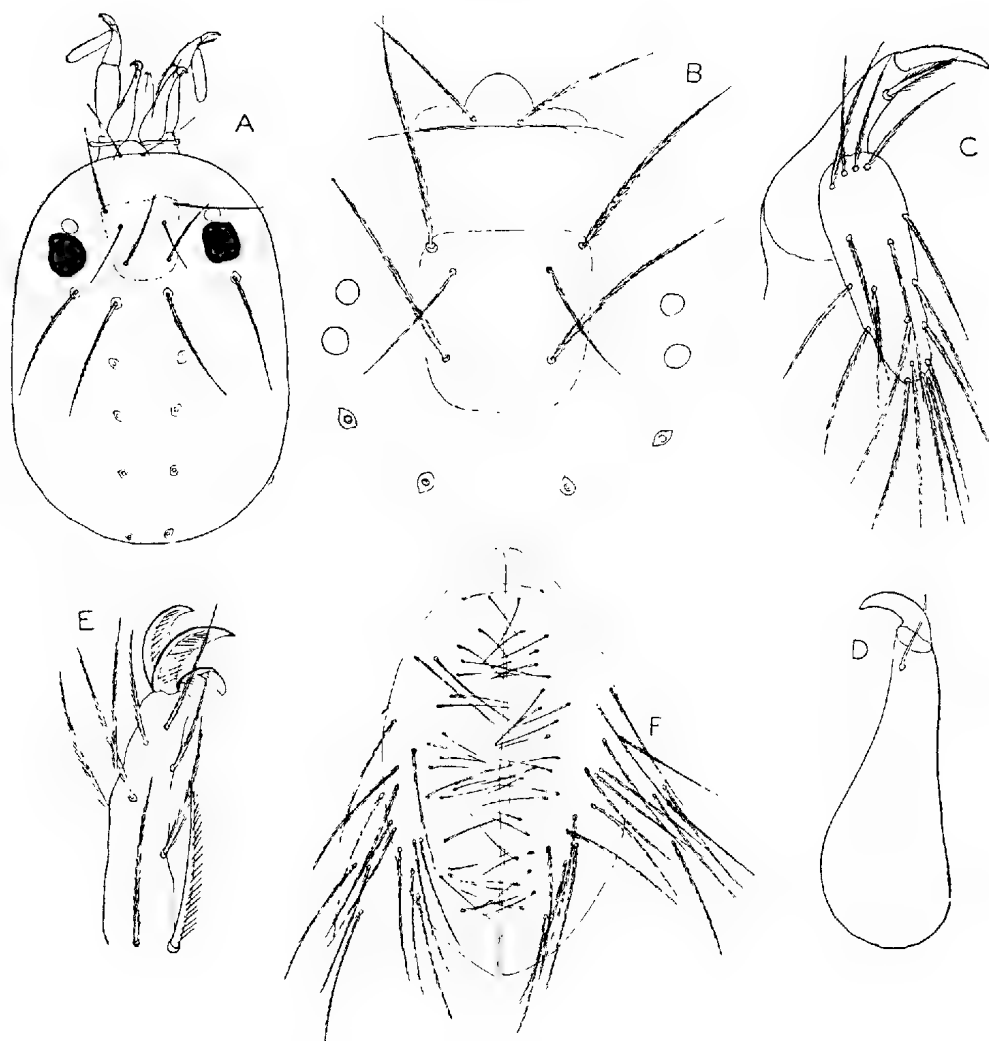


Fig. 4 A—F

*Erythracarus ? parietinum* (Herm.)—A, dorsum; B, anterior portion of dorsum enlarged; C, tip of palpal tibia and tarsus; D, mandible; E, tip of tarsus; F, genital aperture of ♀.

*Description—Female:* Length 720  $\mu$ , width 480  $\mu$ . Eyes ? 2 + 2, one very distinct, behind which is a large dense pigment mass possibly obscuring a second eye on each side. Palpi 290  $\mu$  long, tibial claw and tarsus as figured. Mandibles short, thick, 190  $\mu$  long, basally with only a single distal seta. Median anterior dorsal shield as figured, slightly longer than wide, and widest anteriorly, 100  $\mu$  wide, 110  $\mu$  long, with two pairs of ordinary setae, and a pair of sensillary setae. Anterior sensillary area present with a pair of sensory setae, 108  $\mu$  long, and ciliated their entire length. Dorsal setae strongly ciliated, arranged 4, 2, 2, 2, on small plates. Legs relatively short, I 720  $\mu$ , II 820  $\mu$ , III 800  $\mu$ , IV 880  $\mu$ ; tarsus I 200  $\mu$ , not subdivided, metatarsus I 135  $\mu$ ; all legs with short adpressed, and long outstanding setae; tarsi with paired ciliated claws, and claw-like ciliated empodium. All coxae adjacent. Genital opening as figured.

*Remarks—*Although the preparation of this single specimen is not very good, it appears to be *E. parietinum* (Herm.) as described and figured by Oudemans 1936, except that the size is very much smaller. Oudemans gives the size as: length 1,175  $\mu$ , width 575  $\mu$ .

# NEW GENERA, SPECIES AND RECORDS OF COLLEMBOLA FROM AUSTRALIA, NEW ZEALAND AND NEW GUINEA

By H. WOMERSLEY, A.L.S., F.R.E.S., South Australian Museum

## Summary

Superfamily PODUROIDEA Worn. 1933

Family ACHORUTIDAE Salmon 1941

*Hypogastruridae* Börner 1913, Womersley 1939.

It has been shown by Folsom 1916, Bagnall 1940, and more recently by Salmon 1941, that the generic name *Hypogastrura* Bourlet 1839, revived by Börner 1906, is a homonym and invalid, and that *Achorutes* Templeton 1835, with *A. dubius* Templeton 1935 as genotype, must be used. The necessary change in the family name has been made by Salmon. Similarly Hypogastrurinae must be replaced by Achorutinae, and the old Achorutinae by Neanurinae, with the germs *Achorutes* of Börner being changed to *Neanura* MacGillivray.

NEW GENERA, SPECIES AND RECORDS OF COLLEMBOLA  
FROM AUSTRALIA, NEW ZEALAND AND NEW GUINEA

By II. WOMERSLEY, F.R.E.S., A.L.S., South Australian Museum

[Read 10 April 1942]

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Family ACHORUTIDAE Salmon 1941

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Subfamily ACHORUTINAE Börner 1906

*Achorutes armatus* Nic. 1841—New Zealand: Manaka Hills, Auckland, 12 April 1941 (E. C. C.); Hunika Falls, Auckland, 12 April 1941 (C. S. W. R.).

*Achorutes purpurascens* Lubk.—New Zealand: Nelson, on tobacco plants, 9 October 1933 (E. C. C.).

*Achorutes manubrialis* Tullbg. 1869—New Zealand: Palmerston North, on swedes, September 1930 (W. Cottier).

*Xenylla maritima* Tullbg. 1869—Australia: Bell's Creek, Victoria, 24 June 1941 (R. T. M. P.). New Zealand: Palmerston North, on rotting swedes, 1931 (W. C.); on apple bark, 16 July 1932 (C. O. Burdon); Auckland, under dead white-wax scale, February 1941 (D. S.).

Subfamily NEANURINAE Börner 1906

*Paranura australasiae* Wom. 1935—Australia: Belgrave, Victoria, in rotting tree-fern, November 1941 (O. W. T.).

*Pseudachorutes tasmaniensis* Wom. 1936—Australia: Little Boys' Creek, Victoria, at 3,000-4,000 feet, 24 June 1941 (R. T. M. P.); Bell's Creek, Victoria, at 3,000-4,000 feet, 24 June 1941 (R. T. M. P.); West Tangil, Victoria, 3,000 feet, 23 July 1941 (R. T. M. P.).

***Pseudachorutes pescotti* n. sp.**

(Fig. 1, A-F)

*Description*—Length, to 2.0 mm. Colour, mottled blue-black. Antennae shorter than head-diagonal, ratio of segments = 3:4:3.5:9.5, as figured, III with a pair of subapical, clavate sensillae as figured. Ocelli, eight on each side on deeply pigmented patches. Postantennal organ with four lobes. Tibiotarsus with clavate setae; claws with fine indistinct inner tooth at three-fourths; empodial appendage absent. Furca as figured, dens with four setae, mucro with inner and outer lamellae, one-third length of dens. Dorsal setae short and sparse.

*Location*—Australia: Cumberland, Victoria, at 4,000 feet, 26 May 1941 (R. T. M. P.), several specimens.

*Remarks*—In my key (1939) this species runs down to *P. pacificus* Wom., a New Zealand species, from which it differs in having clavate tibiotarsal setae, and no strong inner tooth to the claw at one-third.

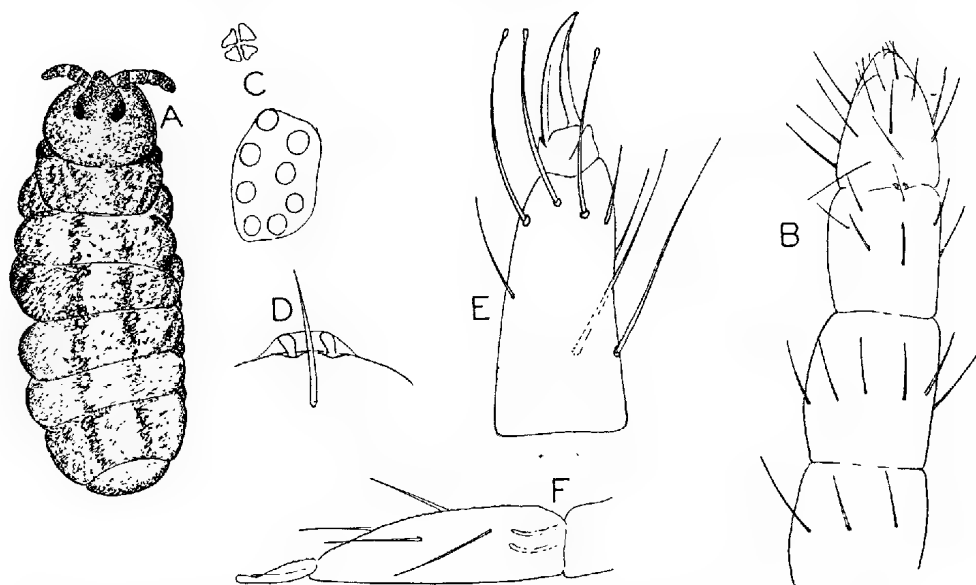


Fig. 1 *Pseudachorutes pescotti* n. sp.: A, dorsal view; B, antenna; C, ocelli and postantennal organ; D, sensory organ on ant. III; E, tibiotarsus and claw; F, furca.

*Neanura muscorum* (Templeton 1935) New Zealand: Grafton Gully, Auckland, in soil, 29 June 1941 (D. S.).

*Neanura hirtellus* v. *cirratu*s (Schött. 1917—Australia: Bell's Creek, Victoria, 24 June, 1941 (R. T. M. P.); West Tangil, at 3,000 feet, 23 July 1941 (R. T. M. P.).

*Neanura radiata* Salmon 1941—New Zealand: Waitakeri Ranges, Auckland, under bark of decaying log, 10 May 1941 (D. S.).

Family ONYCHIURIDAE Börner 1913  
Subfamily ONYCHIURINAE Bagnall 1935

*Onychiurus armatus* (Tullbg. 1869)—New Zealand: Mount Wild, on Begonia bulbs, 15 January 1936 (Fielding).

*Onychiurus ambulans* v. *inermis* Agren. 1903—New Zealand: Blenheim, on seed-crop, April 1935 (E. C. C.); Palmerston North, 15 January 1937 (W. Cottier); Wanganui, 7 October 1938 (A. Dingwell); Owairaka, 18 June 1941 (D. S.); Grafton Gully, Auckland, from soil, 29 June 1941 (D. S.).

Subfamily TULLBERGINAE Bagnall 1935

*Tullbergia tillyardi* Wom. 1939—Australia: Belgrave, Victoria, in rotting tree fern, November 1941 (O. W. T.).

## Superfamily ENTOMOBRYOIDEA Wom. 1933

Family ISOTOMIDAE Schffr. 1896

Subfamily ISOTOMINAE (Schffr. 1898)

***Cryptopygus tasmaniensis* n. sp.**

(Fig. 2, A-D)

*Description*—Length, to 2.25 mm. Colour, deep blue-black except the legs which are white. Antennae longer than the head, ratio of segments = 5:5:5:7.5. Eyes, eight on each side on ocular patch 70  $\mu$  long; postantennal organ 35  $\mu$  from anterior end of ocular patch, elliptical but one side rather straighter than the other and slightly notched, length 21.5  $\mu$ . Ratio of thoracic and abdominal segments = 1.8:1.5:1.2:1.2:1.2:1.4:1.7, VI hidden under V. Tibiotarsus with paired clavate setae, claws without teeth; empodial appendage about one-third claw. Furca short, 0.3  $\mu$ , long as figured, mucro with large subapical tooth. Dorsal setae numerous, uniform, to 54  $\mu$  long.

*Location*—Australia: Mount Wellington, Tasmania, in very large numbers on stones and crossing mountain paths, 30 January 1940 (V. V. H.).

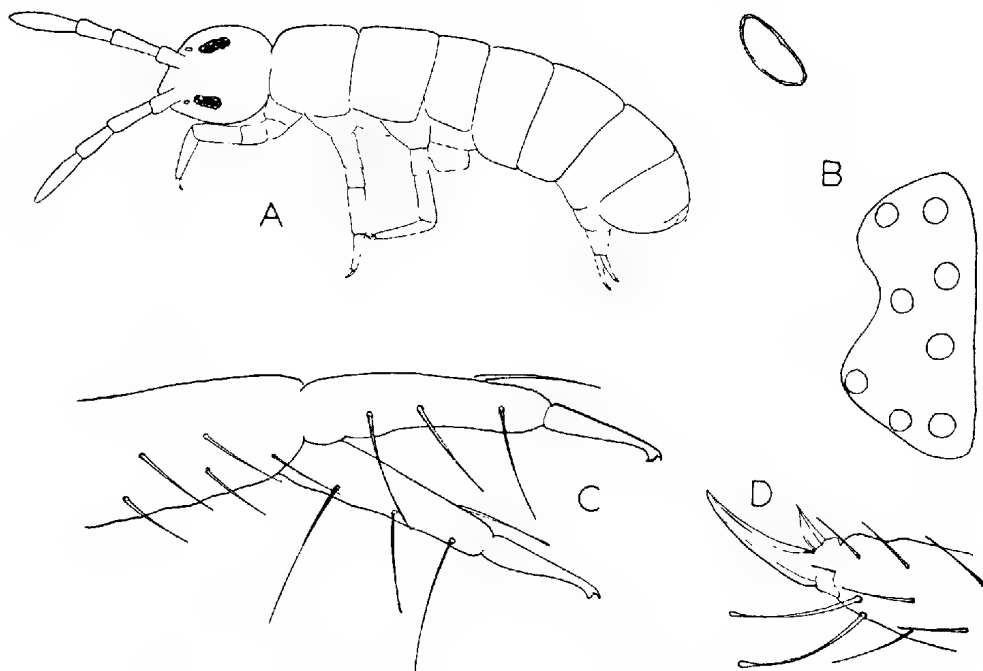


Fig. 2 ***Cryptopygus tasmaniensis* n. sp.**: A, entire; B, ocelli and postantennal organ; C, furca; D, tip of tibiotarsus, claw and empodial appendage.

*Remarks*—Closely related to *C. loftyensis* Wom. but differs in not having any inner tooth to the claw, ratio of antennal segments, etc.

*Folsomia emeraldica* (Rayment 1937)—New Zealand: Palmerston North, in rotting potatoes, 5 May 1931 (W. C.); Auckland, from decaying cherry seed, 11 July 1941 (D. S.).

*Isotomurus palustris* Müll. 1776)—Australia: Cumberland, Victoria, 26 May 1941 (R. T. M. P.); Mount Cascade Creek, Victoria, 26 June 1941 (R. T. M. P.). New Zealand: Nelson, on tobacco plants, 9 October 1933 (E. C. C.).



*Proisotoma minuta* (Tullbg. 1871)—New Zealand: Auckland, on decaying cuttings, 11 July 1941 (D. S.).

*Proisotoma ripicola* Linnan. 1912—Australia: Bell's Creek, Victoria, 24 June 1941 (R. T. M. P.).

*Parisotomina pentomma* (Wom. 1939)—Australia: Belgrave, Victoria, in rotting tree fern, November 1941 (O. W. T.).

Genus **Millsia** nov.

*Description*—Of Isotomid facies. Antennae longer than head, IV with apical knob, III with paired, stout, curved sensory rods. Eyes, eight on each side. Postantennal organ absent. No clavate tibiotarsal setae; empodial appendage present. Furca long, dens baso-laterally with spines and annulated in distal half, mucro falciform. All abdominal segments visible dorsally. Clothing of very long, closely pubescent setae. Genotype **Millsia tiegsi** n. sp.

*Remarks*—This genus is named after my American colleague, Prof. H. B. Mills.

**Millsia tiegsi** n. sp.

(Fig. 3, A-G)

*Description*—Colour white, except for the black ocular patch and a tinge of blue on the apical antennal segments. Length, to 1.0 mm. Eyes, eight on each side, equal. Postantennal organ absent. Antennae longer than head, ratio of

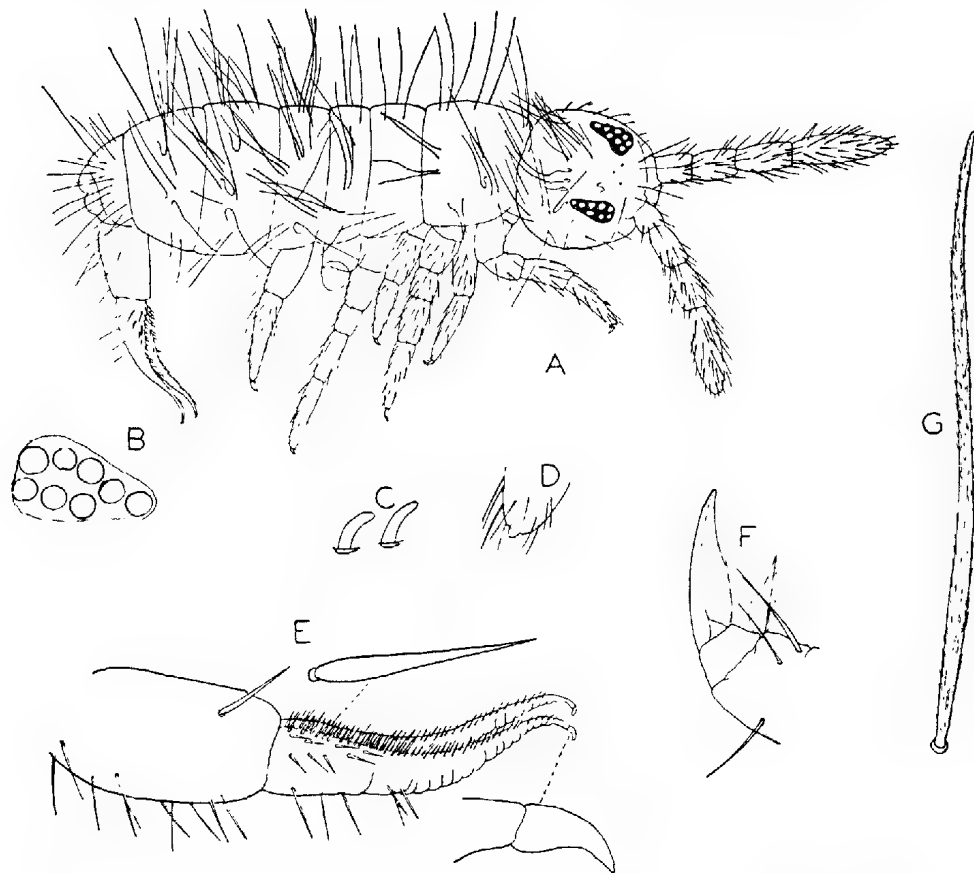


Fig. 3 **Millsia tiegsi** n. g., n. sp.: A, entire; B, ocelli; C, sensillae of ant. III; D, tip of ant. IV; E, furca with details; F, tip of tibiotarsus, claw, and empodial appendage; G, dorsal seta.

segments = 4:5:5:10, IV with apical knob, III with sensory organ as figured. Ratio of length of head, thoracic and abdominal segments = 14:11:5:5:6:9:9:4:3. Tibiotarsi without clavate setae, claw with a long fine inner tooth at a half; empodial appendage pointed with wide inner and narrow outer lamellae. Furca fairly stout, reaching to ventral tube; ratio manubrium:dens:mucro = 10:14:1, dens basally with spines, mucro falciform. Clothing on body of very long, 160  $\mu$ , slender, strongly pubescent setae; on legs of normal short setae.

*Location*—Australia: in rotting log of tree-fern, Belgrave, Victoria, November, 1941 (O. W. Tiegs).

Subfamily ONCOPODURINAE Börner 1913

This interesting subfamily has not hitherto been found in Australia. I am indebted to Dr. O. W. Tiegs for specimens of the following new species collected by him in Victoria. The occurrence of this subfamily in Australia is perhaps the most interesting discovery in the Collenubolan fauna of this country for some years.

***Oncopodura tiegsi* n. sp.**

(Fig. 4, A-D)

*Description*—Length, 370  $\mu$ . Colour, white. Eyes absent; post-antennal organ ? absent. Antennae longer than head, segments III and IV with specialised sensory setae, number uncertain, but approximately as drawn. Furca as figured, but the serrated dental spines may be more than shown.

*Location*—Four specimens from decaying tree-fern log at Belgrave, Victoria, January and February, 1941 (O. W. T.).

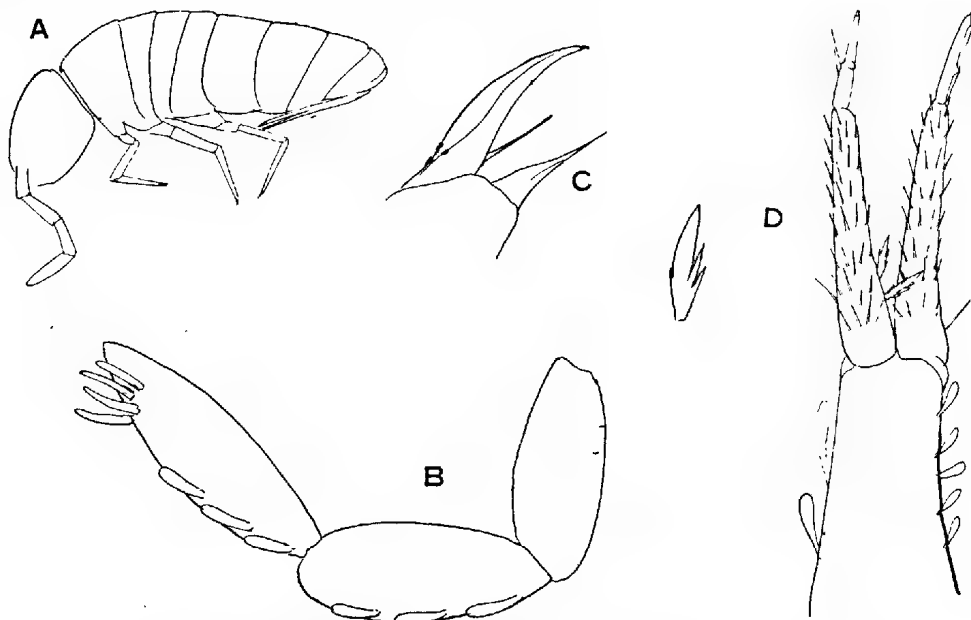


Fig. 4 *Oncopodura tiegsi* n. sp.: A, lateral view; B, antennal segments II-IV; C, claw, and empodial appendage; D, furca and dental spine.

*Remarks*—All previous known species of this genus are cave or soil inhabiting forms. Of the four specimens found, it has been possible to get a mount of one only and this itself is not altogether satisfactory for a complete description. As soon as further material can be obtained a more detailed description will be published.

## Family TOMOCERIDAE (Schffr. 1896)

## Subfamily LEPIDOPHORELLINAE Börner 1906

*Lepidophorella australis* Carp. 1925—New Zealand: Owairaka, in soil, 18 June 1941 (D.S.).

## Subfamily TOMOCERINAE Börner 1906

*Tomocerus tasmanicus* Wom.—Australia: Mount Wellington, Tasmania, 30 January 1940 (V. V. H.).

## Family ENTOMOBRYIDAE Börner 1913

## Subfamily ENTOMOBRYINAE Börner 1906

*Sinella termitum* Schött. 1917—Australia: Brisbane, Queensland, in leaf mould, July 1940 (H. Jarvis); Mount Gambier, South Australia, under log, shore of Leg of Mutton Lake, January 1941 (H. W.).

*Sinella coeca* (Schött. 1896)—New Zealand: Auckland, in termites' nest after treatment, 16 June 1941 (J. Kelsey).

**Entomobrya stramineola** nom. nov.

= *Entomobrya straminea* Börner 1913, Handschin 1920, 1925, nec. Folsom 1898. (Fig. 5, A-C)

*Location*—In numbers in the leaf sheaths of banana at Morobe, New Britain, June 1937 (J. L. F.); and banana and sugar-cane, Brisbane, Queensland, 27 July 1940 (H. Jarvis).

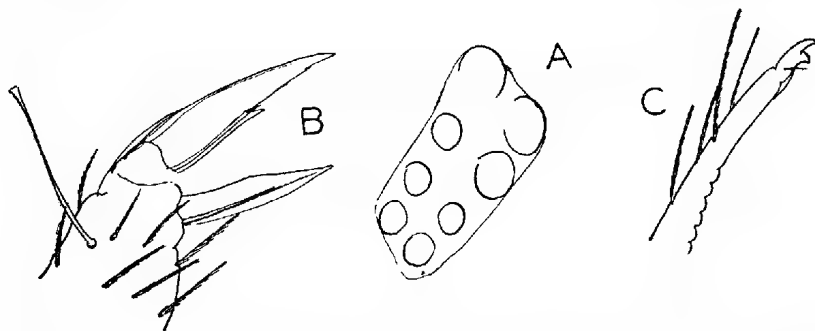


Fig. 5 **Entomobrya stramineola** n. nov.: A, ocelli; B, claw, empodial appendage, and tip of tibiotarsus; C, tip of dens and mucro.

*Entomobrya termitophila* v. *clarki* Wom. 1937—Australia: Bell's Creek, Victoria, 24 June 1941 (R. T. M. P.); Little Boys' Creek, Victoria 24 June, 1941 (R. T. M. P.).

*Entomobrya multifasciata* (Tullbg. 1871)—Australia: Brisbane, Queensland, in leaf mould, July 1940 (H. Jarvis).

*Entomobrya nivalis* Linne 1758—New Zealand: Palmerston North, on rotting swedes, 16 October 1930 (W. C.); Auckland, on roses, 21 April 1941 (J. Kelsey).

*Entomobrya nivalis* v. *immaculata* Schffr. 1896—New Zealand: Palmerston North, on dry rot of swedes, 25 June 1931 (J. G. G.); or new swede area 23 March 1931 (W. C.).

*Sira jacobsoni* Börner 1913—Australia: Cumberland, Victoria, at 4,000 feet, 26 May 1941 (R. T. M. P.).

*Lepidocyrtinus queenslandica* Wom. 1935—New Guinea: Rabaul, on over-ripe and decayed cocoa pods, July 1940 (J. L. Froggatt).

*Lepidocyrtoides cheesmani* Wom. 1937—Australia: Coreen, Queensland, under pig-face in newly burnt scrub April 1941 (Fergusson).

*Mesira flavocincta* v. *unicolor* Wom. 1934—Australia: Coraline, near Mount Gambier, South Australia, January 1941 (H. W.).

*Mesira brunnea* Wom. 1935—Australia: Brisbane, Queensland, in leaf mould, 27 July, 1940 (H. Jarvis).

***Mesira cincta* n. sp**

(Fig. 6, A-B)

*Description*—Length, to 3.7 mm. Colour, yellowish with blue-black markings, scattered on the head, dense laterally on thorax II and III and abdomen I, laterally and along posterior margin on abdomen II, entire band on abdomen III, and laterally on abdomen IV; furca blue near junction of manubrium and dens. Legs with coxae and trochanters blue, femora blue-black at tip, tibiotarsi bluish towards apex. Antennae? longer than head, darkening on apical segments, ratio of segments I:II:III:IV: = 4:5:?:?. Ocelli, eight on each side on black patch. Ratio of lengths of head, thoracic and abdominal segments = 50:40:22:12:15:12:100:10:5. Furca: ratio of manubrium:dens:mucro = 70:85-90:3; dens annulated, distal unannulated part three to four times length of mucro, mucro as figured with two teeth and basal spine. Claws with paired inner teeth at one-third, and one fine distal tooth at three-fourths, with outer basal tooth, praetarsus with small paired outer teeth. Empodium lanceolate, about half length of claw. Tibiotarsus with a long and strong spatulate seta.

*Location*—Australia: Cumberland, Victoria, 26 May 1941 (R. T. M P.).

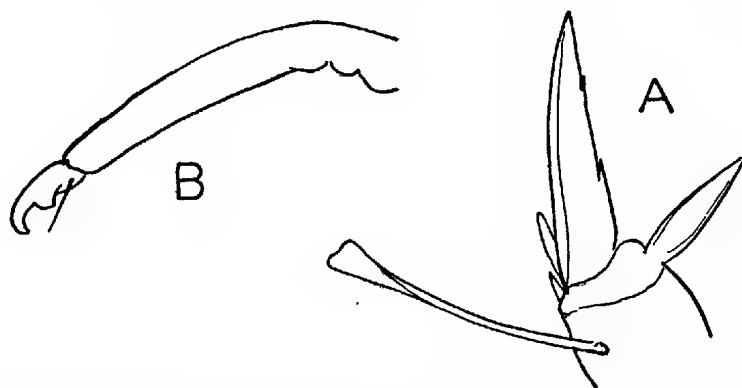


Fig. 6 *Mesira cincta* n. sp.: A, claw, empodial appendage and tip of tibiotarsus; B, mucro and tip of dens.

Genus **Promesira** nov.

For *Mesira nigrocephala* Wom. 1934.

An examination of fresh material from Biloela, Queensland, and Earlsfield, Queensland, April (Fergusson), revealed the presence of bothriotrichia on abd. II, III and IV, and this was later confirmed by a re-examination of my type material.

***Promesira nigrocephala* n. comb.**

A very variable species, ranging from dirty yellow with two transverse dark spots on posterior margin of abd. IV. to entirely black.

*Location*—Australia: Biloela, Queensland, April 1941 (Fergusson); Earlsfield, Queensland, from *Portulaca oleracea* in forest country, April 1941, (Fergusson).

*Urewera flava* Salmon 1938—New Zealand: Auckland, Waitakeri Ranges, 14 July 1941 (D.S.).

*Urewera purpurea* Salmon 1938—New Zealand: Auckland, 23 July 1941 (E. Ballard).

Suborder SYMPHYPLEONA Börner 1941

Family NEELIDAE Folsom 1896

*Megalothorax swani* (Wom. 1932)—Australia: Belgrave, Victoria, in rotting tree-fern, November 1941 (O. W. T.).

Family SMINTHURIDAE Lubbk. 1870

*Sminthurinus aureus* v. *ochropus* (Reuter 1891)—Australia: Little Boys' Creek, Victoria, 24 June 1941 (R. T. M. P.); Bell's Creek, Victoria, 24 June 1941 (R. T. M. P.).

***Parakatianna zebra* n. sp.**

(Fig. 7, A-E)

*Description*—Length, 1,200  $\mu$ . Colour, yellow with transverse dark bands between and in front of the eyes; on the abdomen with black bands as follows; on anterior half with a crescent-shaped band running from middle of dorsum, anteriorly down the sides from the middle of this band a longitudinal band runs almost to the genital segments, and from each side of this two transverse bands run down the sides, these lateral marks give a zebra-like effect; antennae dark on III and IV. Ocelli, eight on each side on pigmented patches. Antennae much longer than head, ratio of segments ca. 20:45:65:150, IV with about 16 subdivisions. Claws as figured, with inner tooth just beyond middle, empodial appendage as figured. Tibiotarsus with three fine clavate setae. Mucro as figured, with toothed inner lamella. Clothing of strong setae, but not so long and strong as in *Katianna*. Female genital appendage as shown.

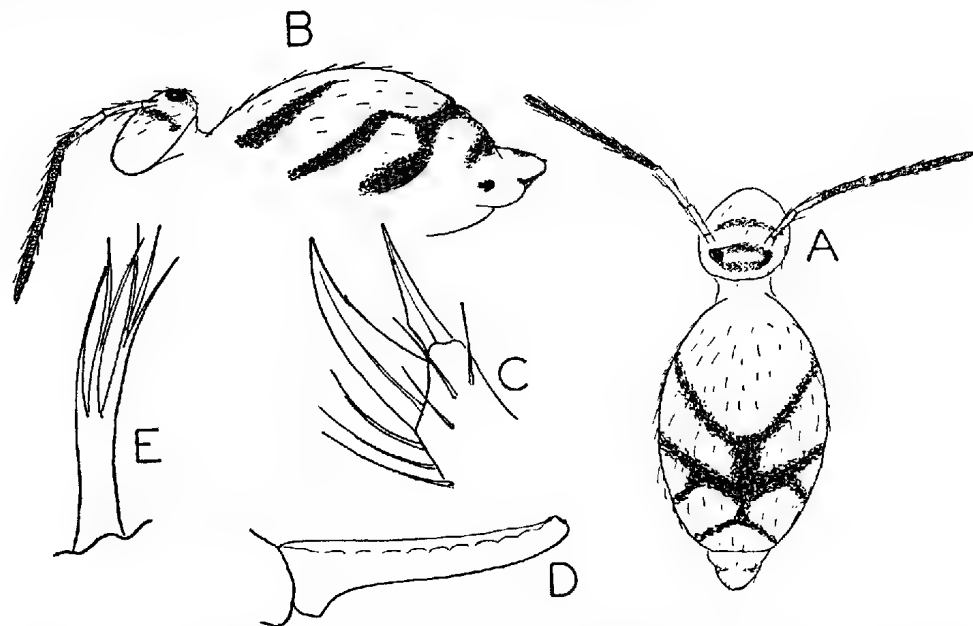


Fig. 7 *Parakatianna zebra* n. sp.: A, dorsal view; B, lateral view; C, claw, empodial appendage and tip of tibiotarsus; D, mucro.

*Location*—Australia: Brisbane, Queensland, a single specimen in leaf mould, July 1940 (H. Jarvis).

*Bourletiella arvalis* (Fetch 1863)—New Zealand: Palmerston North, on new swede area, 25 March 1931 (W. Cottier).

*Deuterostminthurus bicinctus* v. *repandus* Agren. 1903—New Zealand: Lumsden, on dock 22 January 1930 (W. C.); Palmerston North, on broad beans 26 October 1931 (J. G. G.); Avondale, on pumpkins, 1 April 1939 (D. S.).  
*Deuterostminthurus bicinctus* v. *pallipes* Lubk. 1867—New Zealand: localities as above.

***Corynephoria quadrimaculata* n. sp.**

(Fig. 8, A-D)

*Description*—Length, 0.9 mm.. Colour, dorsally yellowish, laterally dirty white with a pair of black spots before anal segments. Eyes, eight on each side, on black patch. Antennae and dorsal club brownish. Antennae not much longer than head, ratio of segments = 12:23:32:73, 1V with 10 subdivisions. Dorsal hump club-shaped, directed backwards and furnished with short spines. Tibiotarsi with three stout spathulate setae. Claw simple, empodial appendage modified as a thin spathulate seta. Furca as figured, ratio of dens: mucro = 70:17.

*Location*—Australia: a number of specimens by sweeping ti-tree, Port McDonnell, South Australia, January 1941 (J. S. W.).

*Remarks*—Related to *C. absoloni* Wom. 1939, but differing in the colour, and in the absence of the small dorsal tubercle in front of the club.

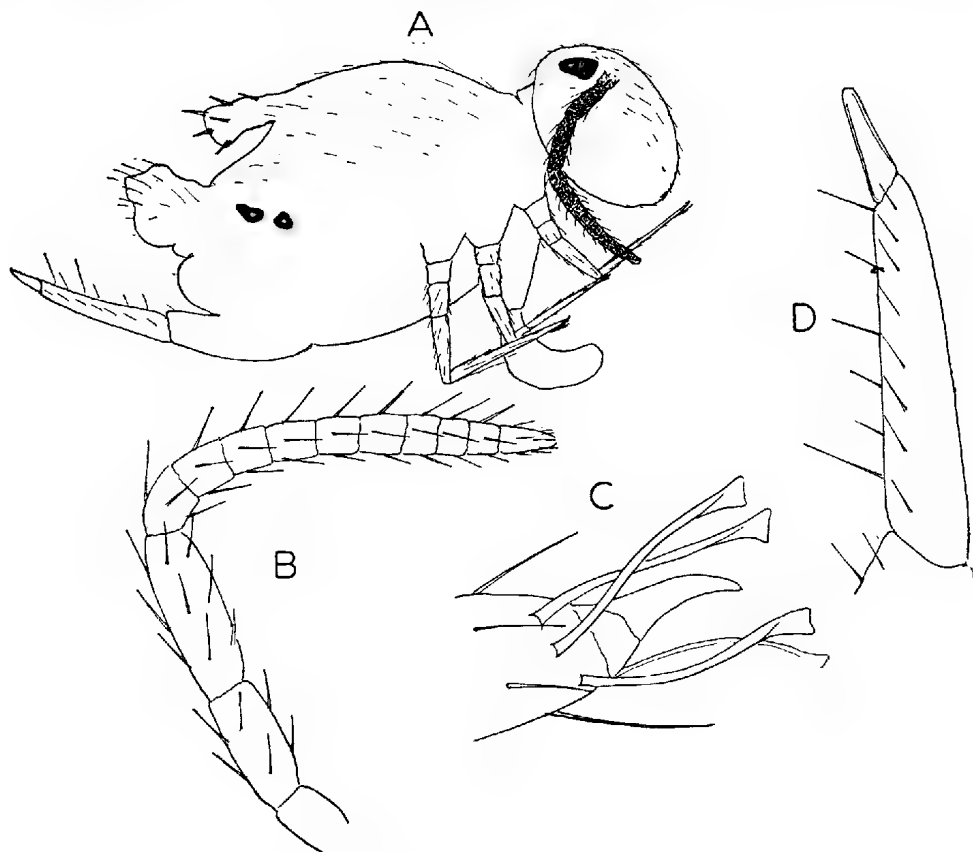


Fig. 8 *Corynephoria quadrimaculata* n. sp.: A, lateral view; B, antenna; C, tip of tibiotarsus; D, mucro and dens.

*Sminthurus viridis* L.—New Zealand: Lumsden, Auckland, on *Plantago major* 21 January 1930 (W. C.).

*Sminthurus regalis* Wom. 1939—Australia: Belgrave, Victoria, in rotting tree fern, November 1941 (O. W. T.).

# **THE MOONAREE STATION SALINE GROUND WATERS AND THE ORIGIN OF THE SALINE MATERIAL**

By S. L. DICKINSON, B.S c. (Melb.), Department of Mines, S.A.

## **Summary**

Moonaree Station property covers an area of nearly 1,000 square miles. situated in a strip of county between Lakes Acraman, Everard, and Gairdner on the northern edge of the Gawler Ranges about 120 miles north-west of Iron Knob. Water for stock is derived almost entirely from bores and wells, the majority of which have been discovered in recent years by the practical operation of a prospecting policy based on a thorough understanding of local underground water conditions. These conditions are fully discussed in the paper. The accompanying map shows all the important features of the property, wells, bores, tracks, paddocks, etc.

## THE MOONAREE STATION SALINE GROUND WATERS AND THE ORIGIN OF THE SALINE MATERIAL

By S. B. DICKINSON, B.Sc. (Melb.), Department of Mines, S.A.

[Read 9 April 1942]

### INTRODUCTION

Moonaree Station property covers an area of nearly 1,000 square miles, situated in a strip of country between Lakes Acraman, Everard, and Gairdner on the northern edge of the Gawler Ranges about 120 miles north-west of Iron Knob.

Water for stock is derived almost entirely from bores and wells, the majority of which have been discovered in recent years by the practical operation of a prospecting policy based on a thorough understanding of local underground water conditions. These conditions are fully discussed in the paper. The accompanying map shows all the important features of the property, wells, bores, tracks, paddocks, etc.

It is important to bear in mind at the outset, that the occurrence in the Gawler Ranges of artesian water, derived from a distant source, is extremely unlikely. The Ranges are composed of a homogeneous igneous rock which appears to have a deep-seated origin. This paper is therefore limited to the consideration of the ground water which has been absorbed in the immediate vicinity of the wells and bores, together with related phenomena.

As the region is one in which the ground waters are, for the most part, saline, the sampling of the waters in wells and bores constituted an important part of the investigation. The analyses of the various samples were made by Mr. T. W. Dalwood, the Government Assayer, and they form the basis of an interesting study on the origin of salinity in ground water, a subject which has not received the attention, the value of which daily experience demonstrates. The causes of ground water salinity have been clearly expounded by R. L. Jack in Bulletin No. 14, G.S., S.A. His statements are generally accepted. This paper simply gives quantitative expression to his deductions; but it is hoped that it may be the beginning of a more intensive inquiry into the causes of salinity, as well as into the properties of the salts found in ground water and their effects on stock.

The paper is written primarily to assist the man on the land in the search for usable ground water in the Gawler Ranges, and secondarily to record information which may be valuable to future investigators.

The subject matter of the paper is divided into the following sections:

- (1) Topography of the Gawler Ranges and of Moonaree property in particular.
- (2) The nature of the rocks in which the ground water occurs.
- (3) The ground water conditions.
- (4) The quality of the ground water.
- (5) The origin of the saline material in the ground water.
- (6) Conclusions.

### (1) TOPOGRAPHY

The Gawler Ranges consist of isolated hills and groups of hills rising to an average height of about 1,200 feet above sea level. The use of the term "Ranges" in this region is somewhat misleading. The isolated hills are really the residual elevated portions of a dissected plateau, and they are best described as residual prominences or "monadnocks." A "monadnock" is the remnant of an original



land surface which persists owing to its superior resistance or to its remoteness from main drainage lines. The following sketch shows the main features of the topography of the Gawler Ranges. The sketch was made from an actual photograph taken from the cairn on Mount Gairdner, looking westward towards Yardea and Thurlga properties. A southern arm of Lake Gairdner occupies the centre of the picture.



Fig. 1

The tops of the hills have a characteristic horizontal profile, and this feature suggests that the hills were at one time part of an old uplifted land surface which has been dissected by a long and continuous erosion process to a stage of full or late maturity. Two erosion cycles are thus in evidence: an old cycle which gave the peneplanation revealed by the even profile of the top of the hills, and a younger cycle marked by the valley floors between the prominences. Dr. C. Fenner states, p. 53, "South Australia, a Geographical Study": "The Gawler Ranges were probably formed in an upwarp during the late Tertiary. If not, we may regard them as a residual monadnock ridge from the pre-Miocene planation, probably due to differential resistance, rounded off by ages of arid erosion." The facts enumerated below favour the second hypothesis of Dr. Fenner's. The hypothesis of an upwarp on an east-west axis through the range is difficult to sustain in consequence of the following observations. Firstly, the divide between the Lake Gairdner and the Lake Gilles surface drainage basins is, for the most part, to the south of the Gawler Ranges proper. Secondly, residual prominences or monadnocks of resistant rock in the pre-Cambrian complex to the south of the Gawler Ranges have elevations comparable with those of the Gawler Ranges and in addition show rudimentary flat-topped profiles. Thirdly, the drainage south of the Gawler Ranges still finds its way into independent inland salt lakes and low-lying depressions and does not possess a general southerly trend. Fourthly, there is no sign of a rejuvenation having occurred in the present normal erosion cycle which has now reached a stage of maturity. There are no signs of dissected pediments, dissected old alluvial fans, nor of newly-formed alluvial fans on the pediments and alluvial aprons flanking the Ranges. Generally, a marked stability of conditions must have persisted for a long period in order to bring about the present topographic form.

The Gawler Ranges, as well as the Kimba district to the south, show all the features indicative of the occurrence of a prolonged period of regional stability in which denudation processes have sculptured the land surface to a form determined chiefly by the relative resistant qualities of the underlying rocks. The felspar porphyry rock of the Gawler Ranges is considerably more durable than the gneissic granites of the Kimba district. The occurrence of the porphyry is therefore, for the most part, co-extensive with the Gawler Ranges. The hills at Moonaree are composed of this felspar porphyry. On account of the uniform character of the porphyry, the hills have few distinguishing features one from another, and gently curving profiles are common to them all.

In the centre of the Moonaree property the ground is relatively high, and from the centre the terrain falls rather rapidly to the levels of the surrounding lakes. The drainage pattern is roughly a radial one, in which the stream courses are short and have fairly steep gradients. They usually preserve their continuity to the edges of the salt lakes, except perhaps in the northern part of the property where they tend to disintegrate on broad flats. Flats of varying width are found around the lakes, and in places they often extend up wide valleys into the hilly regions. In such valleys definite watercourses only occur where the grades of the valley floors steepen. The defined watercourses are usually limited to the upper portions of the wide valleys. The flats which surround and penetrate into the hills seem to be formed by erosion, as they appear to be covered by relatively thin layers of alluvium. Around the margins of the salt lakes it is common to find planed surfaces of basement rocks. Such surfaces may represent local temporary base levels below which the streams from the range fronts cannot incise more deeply. These flats have therefore similar features to the so-called pediments which are typical of mountain fronts in desert or semi-desert regions, although they are not strongly developed here. They will become more and more pronounced as the erosion cycle proceeds towards the old age stage.

The region in question presents one rather interesting point of difference from the usual features exhibited by a mature mountain front in a semi arid region. Instead of composite alluvial fans or bajadas on the outer margins of the pediments salt lakes are found instead and form the zone of deposition. The diagram, below, is taken from Lobeck's *Geomorphology*, p. 244, and shows the features of the usual type. Below it the Moonaree type of terrain is illustrated.

Possibly, with passage of time, the salt lakes will lose their distinctive character. At present they are separate physiographic units. They are all the time shoaling; material, mainly mud, being deposited in them spasmodically by flood water whilst the wind is continually adding its share of transported material in the form of dust, sand, etc., which tends to be caught by the moisture present on the surface of the lake. The fact that the surface of the salt lake is always damp shows that the ground water table is almost at the same level as the lake and evaporation leaves the incrustation of salt on it. In picturing the condition of the salt lake in the old stage of the erosion cycle, it must be borne in mind that the wind will become the main eroding agent in place of water and therefore the limiting factor in wearing down the surface will be the ground water table. (See p. 243, P. G. Worchester, *Geomorphology*.) Worchester states, "Wind cannot erode wet ground; therefore the water table is the base level for the arid cycle of erosion." Hence in following the cycle of erosion from the present stage of maturity to that of old age, it seems likely that the salt lake will first rise to a limiting level dependent on the ability of the streams from the mountain front and of the wind to supply the material. Concurrently the lake will increase in size and will transgress over the pediment eliminating gradually the inequalities, filling hollows and covering up or tending to cover up inselberges, or isolated monadnocks. The limiting level will probably be attained when the run-off from the mountain front is unable to reach the lake. At this stage it also seems likely

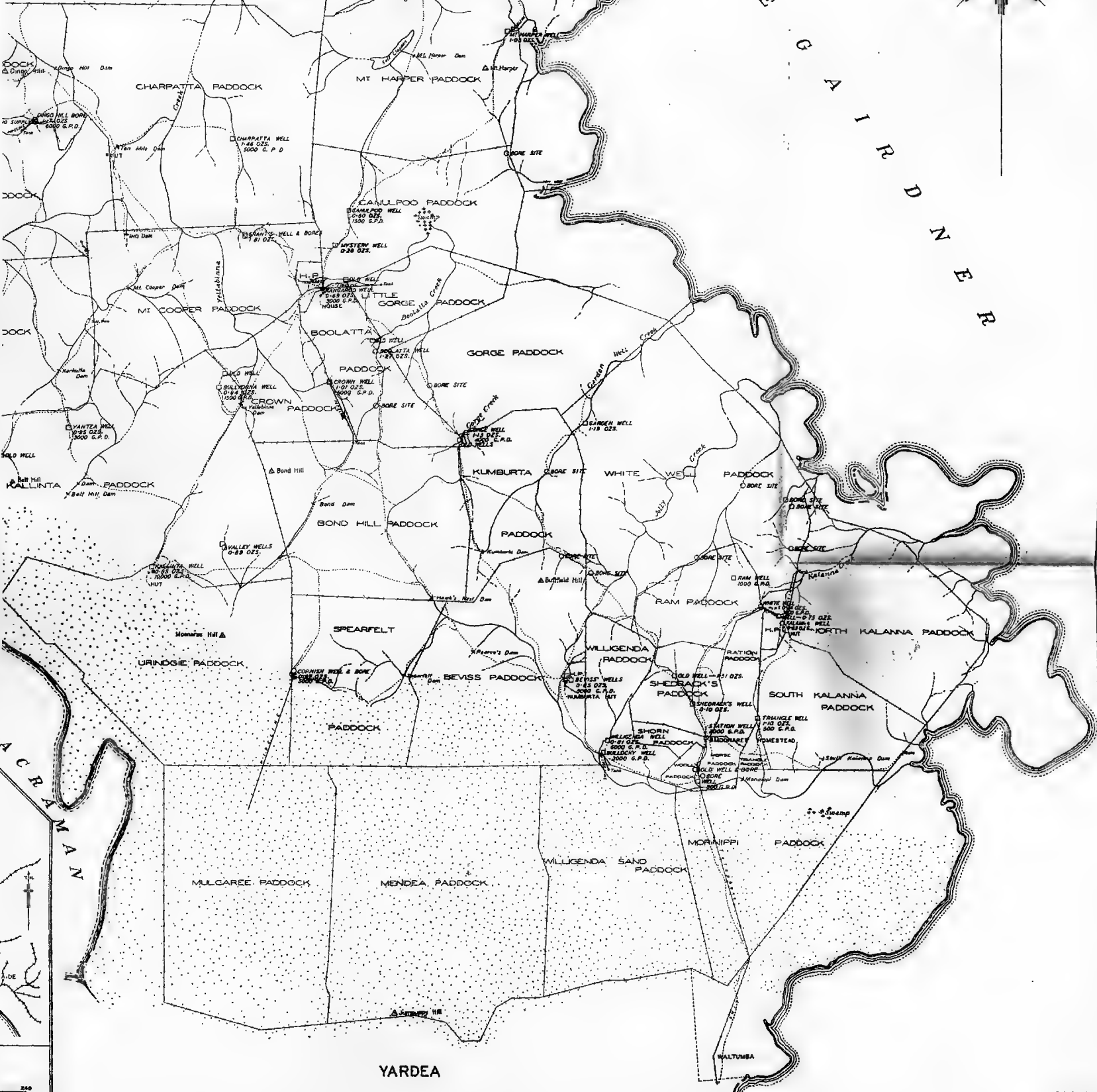
MAP OF  
 EE PASTORAL RUN  
 NGES, SOUTH AUSTRALIA  
 C A L E

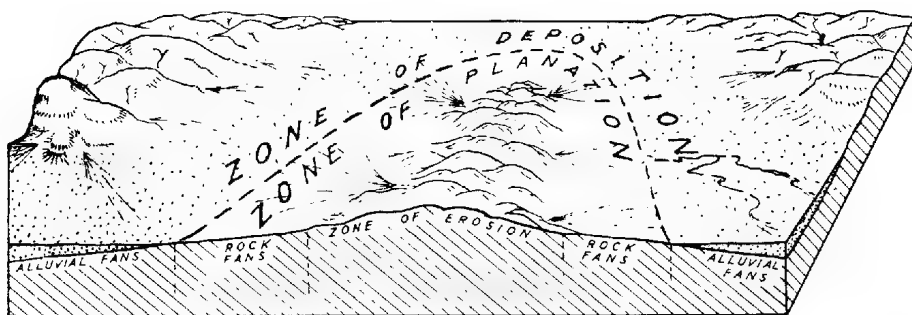
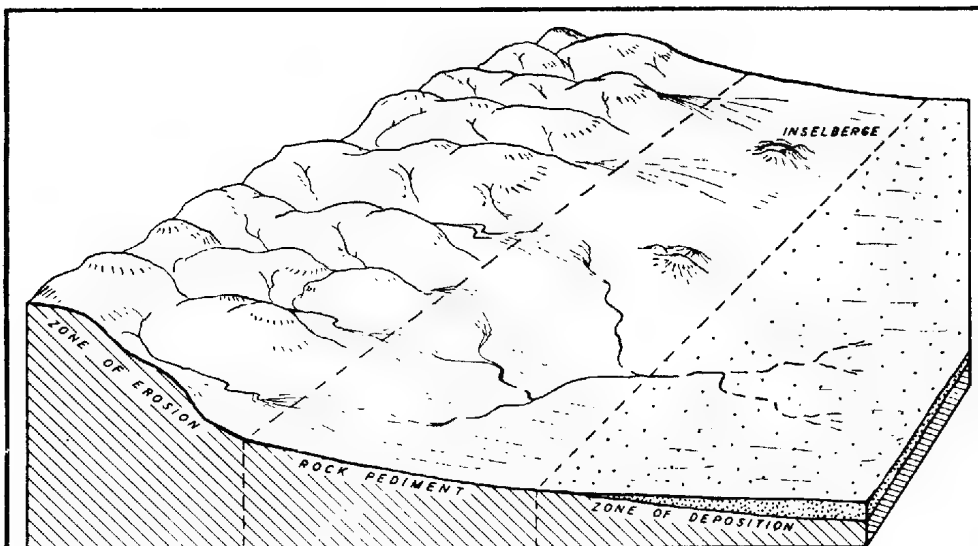


—REFERENCE—

- S & BORE SITES
- S
- ES
- KS
- T SAND
- ONS PER DAY
- WTY—OZS PER GALLON

KOKATHA  
 ASSISTANT GOVERNMENT GEOLOGIST 1941





DIAGRAMS SHOWING MOUNTAIN REGION  
MATURELY DISSECTED IN ARID ENVIRONMENT

AFTER LOBECK

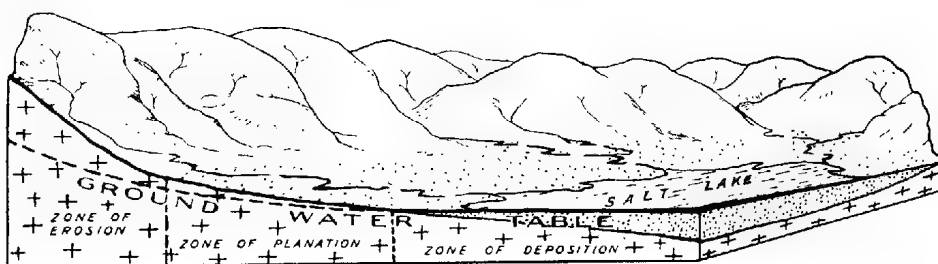


DIAGRAM SHOWING GAWLER RANGE  
MOUNTAIN FRONT AND GROUNDWATER TABLE

*S. B. Dickinson*  
ASST. GOVT. GEOLOGIST  
1941

DEL. W.F.L.

FIG. 2

that the water table will have fallen or will tend to fall below the level of the lake. If this happens, the surface of the lake will become dry and the wind will be able to scour out hollows, build up dunes and in general create a featureless desert waste, the depth of scouring and removal of material depending finally on the level of the ground water table. Such is the probable fate of the salt lake if the present erosion cycle goes to completion without interruption.

A feature of the southern portion of Moonaree is a well-defined sand dune area which extends from Lake Acraman to Lake Gairdner and has a width of about eight miles. The sand appears to be chiefly derived from the disintegration of the felspar porphyry rock, and it is still shifting. The dunes themselves are small and have no definite character. The sand is more of the nature of a thin blanket over the underlying rocks, and it does not mask to any great extent the topography that existed prior to the deposition of the sand. The most striking characteristic of the deposit is the sharp boundary which defines it both on the north and the south sides. There is a slight topographic break to the south between Moonaree and the Gawler Ranges proper. Whether this break is responsible for the presence of sand is a very debatable point, but it is possible that the sand has accumulated on the lee side of the break if it is assumed that the prevailing winds come from the north.

## (2) ROCK TYPES

The ground water at Moonaree is present in three different types of rock, often seen in the one well.

Firstly, ground water occurs in the porous alluvium and detrital material which fill the valleys and form the so-called talus slopes or aprons along the margins of the high ridges and hills.

Secondly, ground water occurs in the weathered top of the felspar porphyry basement rock, a thin layer averaging six to ten feet thick lying immediately under the alluvium. This layer has a porous character and is usually impregnated with varying quantities of secondary calcium carbonate. The weathered porphyry with the calcium carbonate impregnations is generally in the form of flat-jointed sheets which allow the ready percolation of water. This sheeted white rock is locally termed 'artesian rock' owing to its resemblance to the white rock found around mound springs south of Lake Eyre South. A specimen of it was assayed for calcium carbonate and was found to contain 92.7%. It is very similar to travertine limestone and it is most likely formed by the evaporation of ground water containing mineral matter and coming within the influence of capillary and transpiration agencies. It is a good indicator of ground water near the surface. For example, White Well and Crown Well, both shallow wells, 20 feet and 8 feet deep respectively, have strong travertine limestone outcrops adjacent to them. This rock should therefore not be overlooked in water finding, as it points to the presence of ground water at a shallow depth.

Thirdly, ground water occurs in joints in the unaltered felspar porphyry. The joints are very irregular in character. They become tighter and less numerous with depth. The location of a useful bore or well in hard porphyry is therefore wholly a matter of chance depending on the striking of a good water-bearing crack. In general, jointing tends to be developed deeper in the porphyry beneath the main and subsidiary valleys, and therefore the ground water table is more likely to be intersected by jointed rocks in the valley bottoms. It has been suggested that the felspar porphyry occurrence in the Gawler Ranges is of the nature of a volcanic pile composed of acid lava flows, etc. If such is the case, it is reasonable to expect the junction between two lava flows to be a possible water-bearing joint. This idea has not been substantiated so far by any reliable facts, and hence it is of little or no value in predicting possible ground water sources.

### (3) GROUND WATER CONDITIONS

Throughout the entire Gawler Ranges the ground water is saline and, for the most part, it is unfit for stock. There are, however, occurrences of brackish water which are usable, and the finding and utilisation of such water has meant a great deal to the pastoral industry. At Moonaree the discovery of usable ground water has led to the stocking of country which otherwise would have remained idle on account of the difficulties involved in securing surface catchment water supplies.

The usable ground water at Moonaree occurs, as a general rule, in the alluvium covering the basement porphyry rocks. The following discussion is accordingly restricted to this type of occurrence.

At any locality, whether it be in a valley or on the top of a hill, at a certain distance below the surface of the land a depth is reached where the rocks are saturated with water. The water saturating the rocks is known as ground water, and the upper surface of this saturated zone is known as the ground water table. At Moonaree, the surface of the ground water or the ground water table is everywhere below the land surface, except at the salt lakes where the two surfaces are horizontal and practically coincide with one another. At the salt lakes the ground water is all the time evaporating, and hence there is a continual passage of water into the atmosphere. To make up for this loss, the ground water circulates slowly towards the salt lake from the limits of the drainage basin concerned. It is replenished in this basin by that portion of the rainfall which is absorbed by the soil and which escapes the influence of evaporation and transpiration agencies. Where ground water increments from rainfall are relatively high, the ground water is generally comparatively fresh. Where the ground water increments from the rainfall are relatively small in comparison with the percentages of the rainfall transpired, the ground water is generally saline and useless. This is due to the accumulation of salts in the soil in the latter case; and therefore, when there is an excess of absorbed water which is capable of percolating to the ground water table, this water is usually so highly charged with saline material dissolved during its passage through the soil, that it renders saline and keeps saline the main body of the ground water in its immediate vicinity. The absorption of the water which replenishes the ground water is more pronounced in the watercourses where flood-waters are concentrated. As the flood-waters flow towards the low lying ground, they diminish very quickly in quantity and usually only the stronger surface flows are able to discharge directly into the salt lakes. As a consequence of the rapid absorption in the watercourses, little opportunity is afforded the ground water increment to become appreciably saline, and as a result, in alluvial-filled valleys where the stream channels are well defined and where stream gradients are still quite marked, an area of relatively fresh ground water may occur.

The depth of this ground water is variable, but a general average for Moonaree would be about 60 feet. At a few places ground water has been found very near the surface. This abnormality is due to some irregularity in the surface of the basement rocks underlying the alluvium. The Crown Well and the White Well are places where the ground water comes very close to the surface. At both these localities, hard rock bars are exposed in the watercourses, below the wells. These bars operate like walls constructed across surface streams for impounding water, except in these instances, the water is impounded in the alluvium above the rocky bars. Below or down-stream from the bars, the water table is considerably lower.

The possible occurrence of brackish water besides depending on the ratio of the quantity of water absorbed and added to the ground water to the quantity absorbed and transpired to the atmosphere, depends also on the scope of ground water movement at the particular place in question. In general, where stream

gradients are appreciable, the movement of ground water is sufficient to keep the top layers at least, of the water relatively fresh. It is only where conditions of stagnation tend to be produced that the ground water is too saline for use. These conditions are readily recognisable on the surface by a keen observer.

Salinity of ground water is generally due to the building up of salts in practically stagnant ground water. The degree of salinity varies from place to place and chiefly depends on the balance between salts added to ground water by replenishing water from rainfall, and salts removed by ground water movement for the particular place concerned. These two opposing tendencies are governed by three factors, namely: (1) The nature of the topographic relief. (2) The absorptive capacities of the rocks. (3) The vegetation. The first factor has already been dealt with. It determines the capacity of the ground water to circulate once it is given a relatively permeable medium to move in. If the generalised section of the region showing the ground water table and the land surface profile is considered, it will be observed that the ground water table is flatter than the land surface profile. At the salt lake they both coincide, but at the foot of the hills the water table may be 100 feet or more below the surface. If these two profiles are compared, it will be seen that the well-defined curvature in the upper portion of the land surface profile may be correlated with the upper portion of the water table, which is also curved. In this curved portion movement of ground water is quite marked, like that in the youthful part of a surface watercourse. Lower down the watercourse, movement is very sluggish in comparison with that higher up. In a similar way ground water movement is very small in flat country, but the rates of movement in the two cases are not comparable. Where the ground water curve flattens out, the movement of ground water is so retarded that it is almost negligible, but the movement still goes on because it is the only means of replenishing the ground water at the salt lake where continual evaporation is taking place. It follows from the above remarks that at some critical spot not far distant from the foot of the hills, the ground water must permanently have a saline character. The second factor to come under consideration is the permeability of the rocks or the facility with which water can percolate through them. The alluvium and the so-called "artesian rock" are relatively porous and permit the ready percolation of ground water through themselves. On the other hand the hard unweathered felspar porphyry is relatively impermeable, and ground water can only circulate through it along defined cracks and joints which are exceedingly irregular in character and occurrence. For the former rock types, therefore, the facility of ground water percolation is constant from place to place, whilst for the latter type, the felspar porphyry, the facility varies continually and depends on the presence or absence of a pattern of interconnected joints and fractures. The third factor, and possibly a very important one, is the effect of surface vegetation on ground water salinity. This point is very clearly explained by Dr. R. L. Jack (p. 47, Bulletin 14, G.S., S.A.). Comparing thick mallee scrub country with open grasslands, Dr. Jack writes: "Despite very favourable conditions for downward percolation, the mallee transpires so much moisture that there is an accumulation of cyclic salts in the soil, and that, when the exceptionally heavy rains do provide an excess over soil evaporation and transpiration to form ground water, the excess is contaminated by these accumulated salts. On grass lands, and ultimately on cleared and cultivated land, a greater proportion of the rainfall is available for percolation, and consequently a layer of good water is formed."

To complete the discussion of ground water conditions, it is necessary to consider the question of supply. Having once located usable water, what are the conditions favouring the occurrence of suitable supplies of such water? Firstly, the rocks in which the usable water occurs must have a definite porous and jointed character to allow the passage of water. Secondly, the topography must be sufficiently pronounced to maintain an appreciable ground water move-

ment. Thirdly, the configuration of the hard rock underlying the alluvium must be known because it determines the zones or channels in which ground water movement is concentrated. Just as surface water tends to flow in a channel, so ground water tends to move more freely in the channels in the basement rocks, and the greatest supply of water is therefore obtained when a well or bore is sunk into such an underground channel. The supply in this underground channel is greatest where the channel is constricted. For example, it will be greatest at a point where surface land features suggest that the valley walls may locally be closer together; where the V-shaped cross section of the valley has a more acute angle. The position of this underground channel in a valley can rarely be found by one bore-hole, particularly if the valley is wide. Usually a series of bores are required. The following diagram illustrates the best position for a bore or well, once the ground water has been proved usable for watering stock.

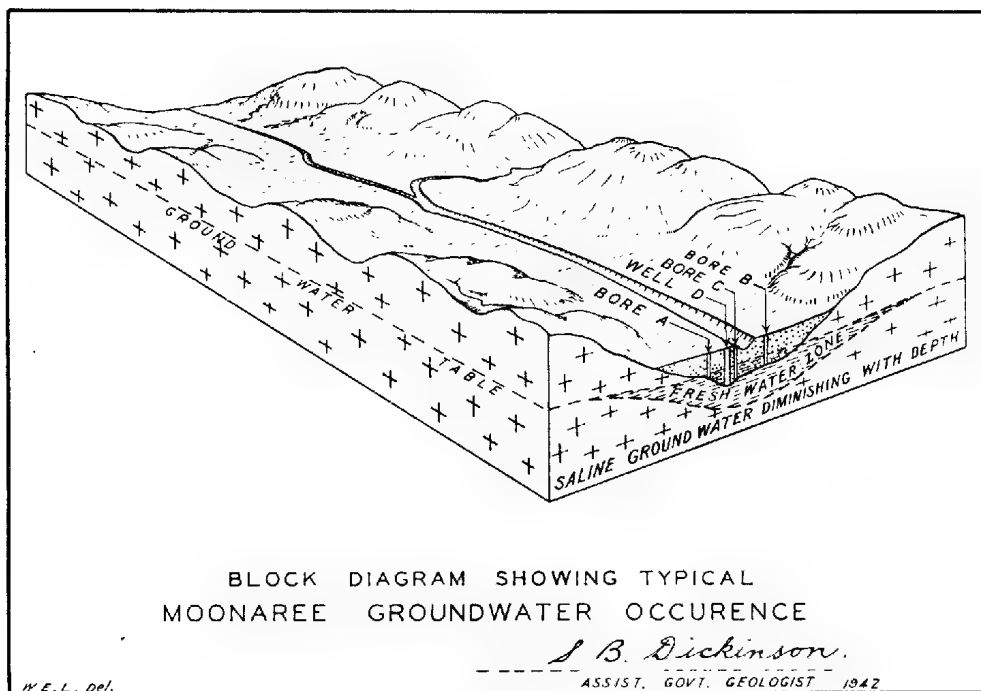


FIG. 3

#### (4) THE QUALITY OF THE GROUND WATER

The ground water of the Gawler Ranges contains saline matter in varying amounts according to locality and depth. Samples of the majority of Moonaree Station bores and wells were taken and they were analysed by Mr. T. W. Dalwood, the Government Assayer. The analyses are given in the following table. All these waters are suitable for sheep. The ground water of Grant's Bore is considered to possess too high a salinity for use under normal conditions, although in emergency it could be used as its value is less than  $2\frac{1}{4}$  ozs., the maximum salinity tolerable by sheep.

#### (5) THE ORIGIN OF THE SALINE MATERIAL IN THE GROUND WATER

From the above analyses, a study of the sodium and chlorine ions has shown that the amounts of sodium and chlorine in the individual samples closely approximates to the amounts of sodium and chlorine in ocean salt, if ocean salt is dissolved in pure water to produce saline waters having total salinities equivalent to that of the Moonaree samples. This result is shown graphically in fig. 4 and 5.





DIAGRAM SHOWING SODIUM AND CHLORINE ION CONTENTS  
OF

USABLE GROUNDWATERS IN WELLS AND BORES OF  
MOONAREE STATION, GAWLER RANGES, S.A.

(COMPARED WITH CURVES FOR SOLUTIONS OF OCEAN SALT)

Chlorine Ion \_\_\_\_\_  $\ominus$  Sodium Ion \_\_\_\_\_  $+$   
Theoretical curves for Cl and Na ions in corresponding saline waters containing ocean salt, the composition of which is the average of 77 samples collected by the Challenger Expedition. Analyses by W. Dittmar.

**OCEAN WATER**  
(DITTMAR'S AVERAGE ANALYSIS OF SALT CONTENT)

	PARTS PER 100,000	PER CENT
CL	1932.4	55.292
BR	6.6	0.188
SO <sub>4</sub>	269.6	7.692
CO <sub>3</sub>	7.4	0.207
NA	1072.2	30.593
K	38.2	1.106
CA	42.0	1.197
MG	13.6	3.725
	3500.0	100.000

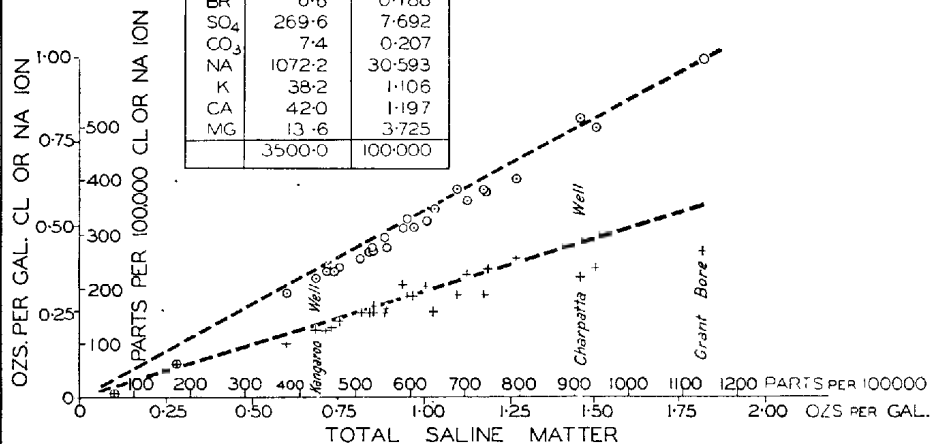


FIG. 4

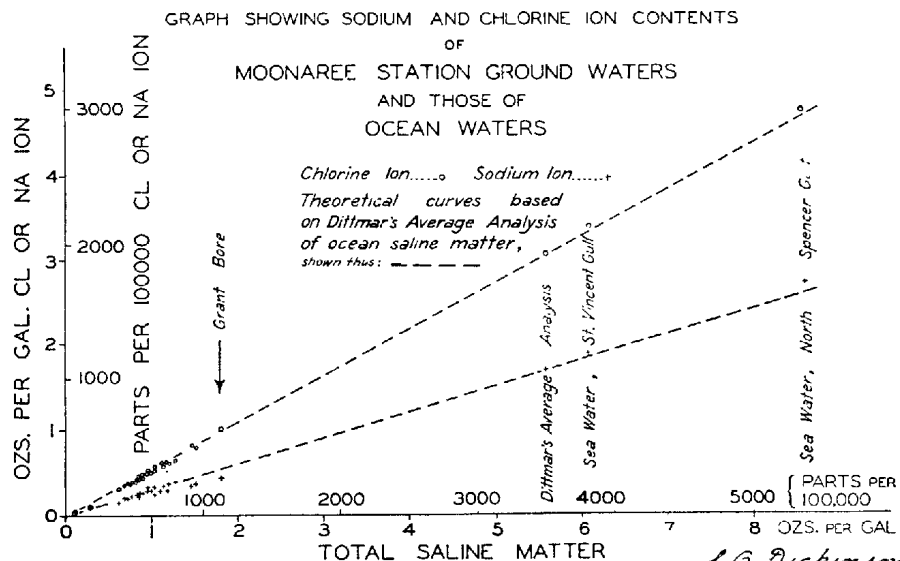


FIG. 5

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ASSIST. GOVT. GEOLOGIST  
1941 B.F.C.

N.B. The Sodium Ion content expressed graphically represents Total Alkali (Na + K).

Fig 4 shows the various amounts of sodium and chlorine expressed in ounces per gallon and parts per hundred thousand for each water sample. The dotted line represents the corresponding values for water containing ocean salt. The composition of ocean salt used for the comparison is that calculated by W. Dittmar from the analyses of 77 samples collected by the Challenger Expedition from various localities and depths.

Fig. 5 carries the comparison still further because it shows the actual values for the quantities of sodium and chlorine in ocean water (Dittmar's quantities), and it also shows the sodium and chlorine values for two samples of sea water collected by Dr. R. L. Jack, one from St. Vincent Gulf, about 15 miles west of Adelaide, the other from the north end of Spencer Gulf. The beginning of this graph is simply a replica of fig. 4 on a smaller scale. The theoretical line is extended to show how the prolongation of the average curve for the Moonaree samples would approximately intersect the ocean water analyses. It is hoped to obtain samples of saline water between two and five ounces per gallon from other localities at Moonaree, to fill the large gap in the graph between the usable water values and the ocean water values, whereby the correlation of the percentage compositions of the salts may be more definitely demonstrated.

These graphs quantitatively support the conclusions reached by Dr. R. L. Jack, that the saline material causing ground water salinity is the so-called "cyclic salt" which occurs in the atmosphere and which is brought to the earth by rain. Dr. Jack (p. 7, Bulletin 14, G.S.S.A.) quotes analyses of rain water containing appreciable quantities of sodium and chlorine. The presence of these minerals in rain water was suggested by Gray in New Zealand (A.A.A.S., 1, 1887). This cyclic salt has a quantitative mineral association similar to that of ocean salt, and Dr. Jack suggests that its mode of origin may be the evaporation of sea spray.

The only other possible source of salt in these regions of inland drainage is from the rocks themselves. The Gawler Ranges, as previously stated, are composed of felspar porphyry. W. S. Chapman made three analyses of the felspar porphyry and they are given in vol. 18, of A.A.A.S., Perth, 1926, at the conclusion of a brief resume by Sir D. Mawson on the Igneous Rocks of South Australia. The sample localities are some distance from Moonaree, but the rocks are identical in character and occurrence with the Moonaree porphyries. The analyses are as follows:

follows:				Felspar Porphyry		
				Paney Bluff	One mile west of Paney Bluff	Four miles north of Burkett's Hill
SiO <sub>2</sub>	-	-	72.22	71.48	68.90	
Al <sub>2</sub> O <sub>3</sub>	-	-	14.35	14.73	14.43	
Fe <sub>2</sub> O <sub>3</sub>	-	-	1.22	1.14	1.91	
FeO	-	-	1.69	1.16	2.80	
MgO	-	-	0.30	0.25	0.33	
CaO	-	-	1.22	0.54	0.92	
Na <sub>2</sub> O	-	-	2.50	2.74	3.07	
K <sub>2</sub> O	-	-	5.12	5.68	5.70	
H <sub>2</sub> O at 110° C.	-	-	0.68	1.08	0.87	
H <sub>2</sub> O at 100° C.	-	-	0.12	0.32	0.29	
CO <sub>2</sub>	-	-	0.22	0.12	0.23	
TiO <sub>2</sub>	-	-	0.42	0.35	0.69	
P <sub>2</sub> O <sub>5</sub>	-	-	0.07	0.04	0.03	
Cl	-	-	0.02	0.04	0.03	
FeS <sub>2</sub>	-	-	0.06	0.14	0.15	
MnO	-	-	0.02	0.10	0.03	
Total	-	-	100.23	99.91	100.38	

Note—SO<sub>3</sub>, NiO & CoO, BaO, LiO, V<sub>2</sub>O<sub>5</sub>, no values.

It will be seen that the chlorine content of these samples is very low; therefore it seems very doubtful if weathering has released the quantity of that element that now appears in the soil, ground water, and on the salt lakes. We must look, therefore, to some other source for the chlorine ion, now so widespread in the region.

The other interesting feature in these rock analyses in connection with ground water salinity is the potassium content of the porphyry. It is typically an alkali rich rock. The  $K_2O$  values are high, namely, 5.12, 5.68, and 5.70, respectively. If the saline matter found in the ground water were derived at least in part from the weathered country rock, would not there be a high potassium content in the ground water of an alkali-rich rock region compared with the potassium content in the ground water of a region not characterised by the presence of alkali rocks?

The following table gives the percentage content of potassium in salt samples collected at various inland salt lakes. It was prepared by Dr. L. K. Ward, the Government Geologist, in the course of an inquiry into the possible exploitation of potassium rich brines in South Australia. (See also the note on "Potash," p. 9, No. 21, "Mining Review.") The table is as follows:

Material tested					Percentage of Potassium
Lake Hart salt	-	-	-	-	0.20
Lake Dutton salt	-	-	-	-	0.34
Pernatty Lagoon salt, northern shore	-	-	-	-	0.23
Pernatty Lagoon salt, western shore	-	-	-	-	0.21
Pernatty Lagoon, salt from brine	-	-	-	-	0.36
Lake Gairdner salt	-	-	-	-	0.25
Ocean salt	-	-	-	-	1.11

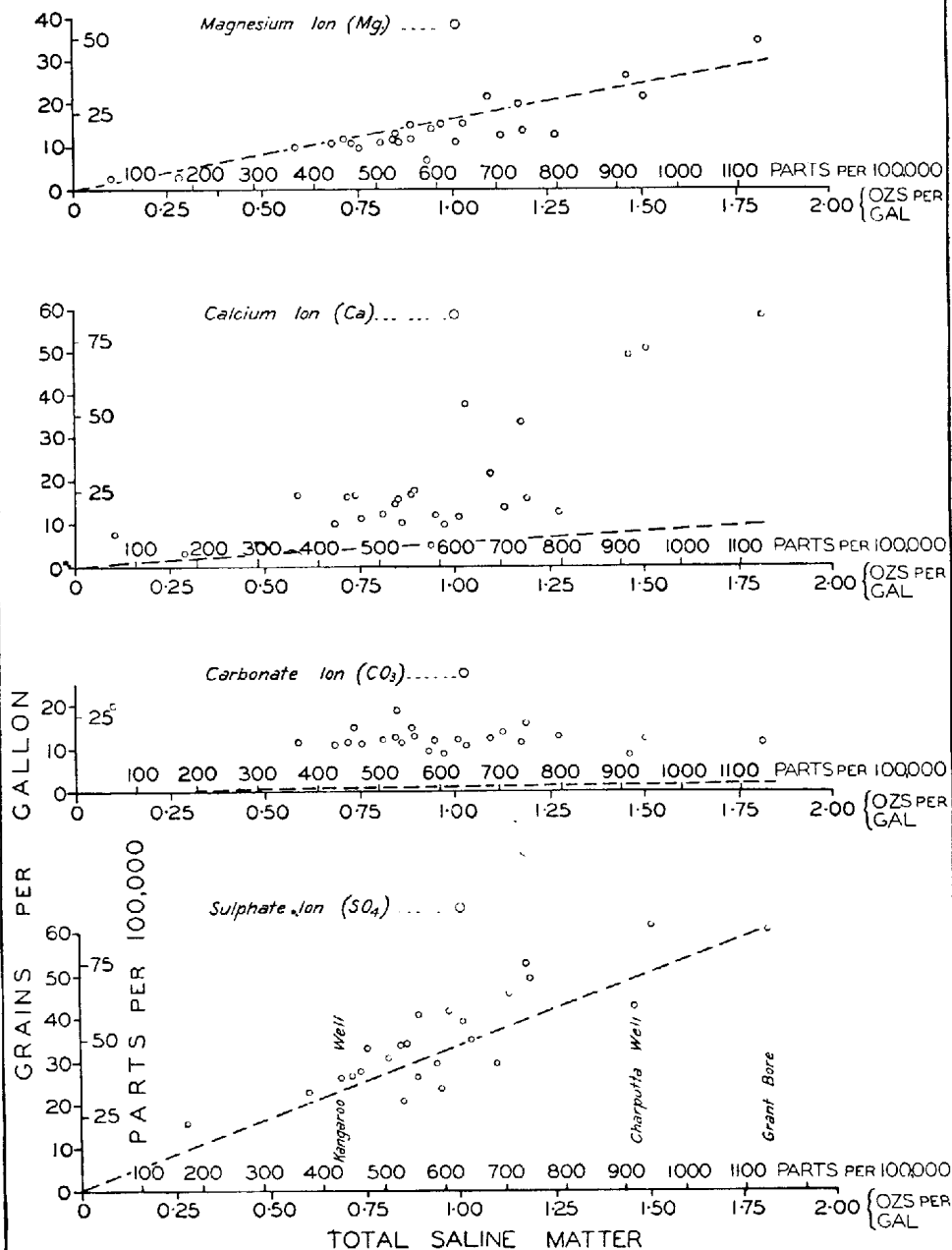
From this table it will be seen that Lake Gairdner salt, occurring as it does in an alkali-rich rock environment, is no richer in potassium than the other salts which occur in areas practically free of outcropping alkali-rich rocks. This non-appearance of a potassium-rich salt on Lake Gairdner is indirect evidence against the possible origin of saline material in ground water resulting from the disintegration of the felspar porphyry. Doubtless some contamination of ground water must be due to the decomposition of the felspar porphyry, but it appears to be of negligible amount in the general consideration of the origin of saline material in ground water.

The possible origin of the saline material from so-called "connate water" cannot be accepted, because there is no evidence of its present or probable former occurrence in this Gawler Range region. "Connate water" is defined as that water which has remained in sedimentary rocks since their time of deposition either in a fresh water or marine environment. "Connate water" is often found in regions where sedimentary basins have been raised above the sea level by epeirogenic movements. The complete absence of sedimentary rocks in the Gawler Ranges, together with the strong impression that the Ranges are residual hills from a pre-Miocene planation, makes the occurrence of "connate water" in this region extremely unlikely.

In brief, the analyses of the Moonaree samples, in conjunction with the above discussion, indicate fairly conclusively that the salt of the interior salt lakes and ground water is derived mainly from a source which has the same composition as ocean salt. This source is assumed to be the "cyclic salt" which from its detection in rain water has been proved to be present in the atmosphere. Furthermore, the "cyclic salt" appears most likely, initially, to be formed over the ocean in part of a process similar to that suggested by Dr. R. L. Jack, namely, in the evaporation

DIAGRAM SHOWING  
MAGNESIUM, CALCIUM, CARBONATE AND SULPHATE ION CONTENTS  
OF  
USABLE GROUND WATERS IN WELLS AND BORES  
OF

MOONAREE STATION, GAWLER RANGES, S.A.  
(COMPARED WITH CURVES FOR SOLUTIONS OF OCEAN SALT)



Theoretical curves for respective  
ions from Dittmar's average  
composition of ocean salt. ....

FIG. 6

S. B. Dickinson.  
ASSIST. GOVT. GEOLOGIST  
1941

R.F.C.

of sea spray. From the ocean the "cyclic salt" is probably flown inland and subsequently brought down by the rain, to be accumulated in the inland basins from which there is no escape except by the way it came.

On this latter thought a little amplification is necessary, because in considering the saline contents of the ground water, it is advisable to allow for the possibility of a certain amount of salt in the ground water resulting from a process involving the redistribution of salt, whether it be from wind-blown saline material, wind-blown soil, sand, etc. Such a process is practically incapable of quantitative expression, but it must occur and influence salinity value.

Besides the chlorine and sodium ions, which form the greater bulk of the saline material in the ground waters, there are other ions present, namely, sulphate, carbonate, magnesium, calcium, etc. The quantities of these ions are shown graphically in fig. 6, in a manner similar to that used in fig. 4 and 5, except that the vertical scale is enlarged five times to show up the values of these ionic contents more clearly. It is difficult to express an opinion on the relations of these ionic contents to those in similar solutions of ocean salt. The question of relative solubilities has an important bearing on the possible comparisons. For example, the solubility of gypsum, calcium sulphate, is a function of the sodium chloride content of the water. However, the behaviour of these small constituents of saline water is of minor importance compared with that of sodium chloride which shows so strikingly the correlation between ground water salts and ocean salt.

#### (6) CONCLUSIONS

It is hoped that the above detailed explanation of the ground water conditions at Moonaree will assist those interested in water finding in the Gawler Ranges. At the same time it is hoped that the explanation will tend to dispel some of the many misconceptions concerning the occurrence of ground water which are so common and on which the art of water divining sustains its perennial glamour.

Moonaree presents a curious anomaly compared with the general run of the Gawler Ranges. Although it is almost completely surrounded by low-lying salt lakes, and in spite of the concentration of salt around it, it has a better ground water supply than most sheep stations in the Gawler Ranges. The Mullaroo peninsula, at the southern end of Lake Gairdner, has ground water supplies comparable to those at Moonaree. Mullaroo also occurs in a similarly isolated environment. The questions naturally arise: Do these areas possess certain distinctive features which favour the more prolific occurrence in them of usable ground water? Do they only have better ground water supplies by reason of the fact that they have been more thoroughly and more methodically explored? It is premature to attempt to answer either of these questions, but it is hoped as opportunities arise, to extend this type of examination to other pastoral properties, whereby facts may be gained to enable an explanation to be given as well as to specify more definitely the ground water conditions.

# **THE PHASE AND AMPLITUDE OF AUSTRALIAN MEAN MONTHLY TEMPERATURES**

By J. A. PRESCOTT, Waite Agricultural Research Institute

## **Summary**

During the course of an investigation into the relationship between temperature and evaporation at certain Australian recording stations it was observed that significant differences in the phase of the temperature curves were to be observed for different parts of Australia. These differences appeared to be sufficiently important to justify a more complete examination of all available data by the method of Fourier analysis. By means of this analysis the three principal constants of the curve representing the march of monthly temperatures can be calculated. These three constants are the mean annual temperature, the amplitude of the swing of the curve about the mean, and the phase of the curve, that is, its position along the time axis. Low amplitudes are well known to be characteristic of coastal climates and high amplitudes of continental climates, but less is known regarding the phase except that oceanic climates would be expected to have a late phase owing to the great heat capacity of the oceans.

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[Read 14 May 1942]

During the course of an investigation into the relationship between temperature and evaporation at certain Australian recording stations it was observed that significant differences in the phase of the temperature curves were to be observed for different parts of Australia. These differences appeared to be sufficiently important to justify a more complete examination of all available data by the method of Fourier analysis. By means of this analysis the three principal constants of the curve representing the march of monthly temperatures can be calculated. These three constants are the mean annual temperature, the amplitude of the swing of the curve about the mean, and the phase of the curve, that is, its position along the time axis. Low amplitudes are well known to be characteristic of coastal climates and high amplitudes of continental climates, but less is known regarding the phase except that oceanic climates would be expected to have a late phase owing to the great heat capacity of the oceans.

The method employed in the analysis was the standard method of fitting to the data a Fourier series of the type

$$u = a_0 + a_1 \cos x + a_2 \cos 2x + a_3 \cos 3x + \dots \\ + b_1 \sin x + b_2 \sin 2x + b_3 \sin 3x + \dots$$

where  $u$  is the temperature for any month.

$x$  is the period expressed in degrees over a range 0-360° corresponding to the 12 months of the year and represented in this case by the period 0° for 15 January, 30° for 15 February, etc., to 330° for 15 December.

$a$  and  $b$  are constants, and  $a_0$  is the general mean.

The equation can also be expressed in the form:

$$u = a_0 + c_1 \sin(x + \phi_1) + c_2 \sin(2x + \phi_2) + c_3 \sin(3x + \phi_3) + \dots$$

where  $c$  is the amplitude and  $\phi$  the phase angle of each term and

$$a_1 \cos x + b_1 \sin x = c_1 \sin(x + \phi_1)$$

and similarly for  $2x$  and  $3x$ .

After a preliminary trial using the first six terms of the Fourier series, that is,  $x$ ,  $2x$ , up to  $6x$ , it was found sufficient to employ only the first three, the method used being that recommended by Whittaker and Robinson (1940). The data were those of Pamphlet 42 (1933) of the Council for Scientific and Industrial Research prepared by the Commonwealth Meteorological Bureau. These include monthly temperature data for 389 stations. The mean temperature was calculated from the average of the maximum and minimum for each month and the results for each station entered on a form specially prepared to simplify the arithmetical work involved.

Except for the tropical stations where the sun is overhead twice each summer, the first term was found to account so nearly for the greater part of the amplitude of the curve that only this term was used in determining the phase angle and the amplitude for each temperature curve.

These values,  $\phi_1$  and  $c_1$ , were then entered on maps. The map representing values of  $a_0$  is the familiar map of the isotherms of mean annual temperature and need not be repeated here. The maps recording lines of equal value for phase and amplitude are given in fig. 2 and 3.



The actual meaning of these constants can best be understood by reference to fig. 1 where the temperature curves for the three stations, Daly Waters, Mount Barker (W. Aust.) and Hillston, are shown. The actual equations for these stations are:

For Daly Waters -  $u = 80.36 + 8.92 \cos x - 2.70 \cos 2x + 0.03 \cos 3x - 2.77 \sin x - 0.35 \sin 2x + 0.08 \sin 3x$

$$c_1 = 9.35$$

$$\phi_1 = 107.2^\circ$$

For Mount Barker  $u = 57.96 + 8.10 \cos x - 0.05 \cos 2x + 0.10 \cos 3x + 2.35 \sin x + 0.55 \sin 2x - 0.25 \sin 3x$

$$c_1 = 8.43$$

$$\phi_1 = 73.8^\circ$$

For Hillston -  $u = 64.00 + 15.42 \cos x + 0.05 \cos 2x + 0.08 \cos 3x - 0.37 \sin x + 1.02 \sin 2x + 0.13 \sin 3x$

$$c_1 = 15.42$$

$$\phi_1 = 91.4^\circ$$

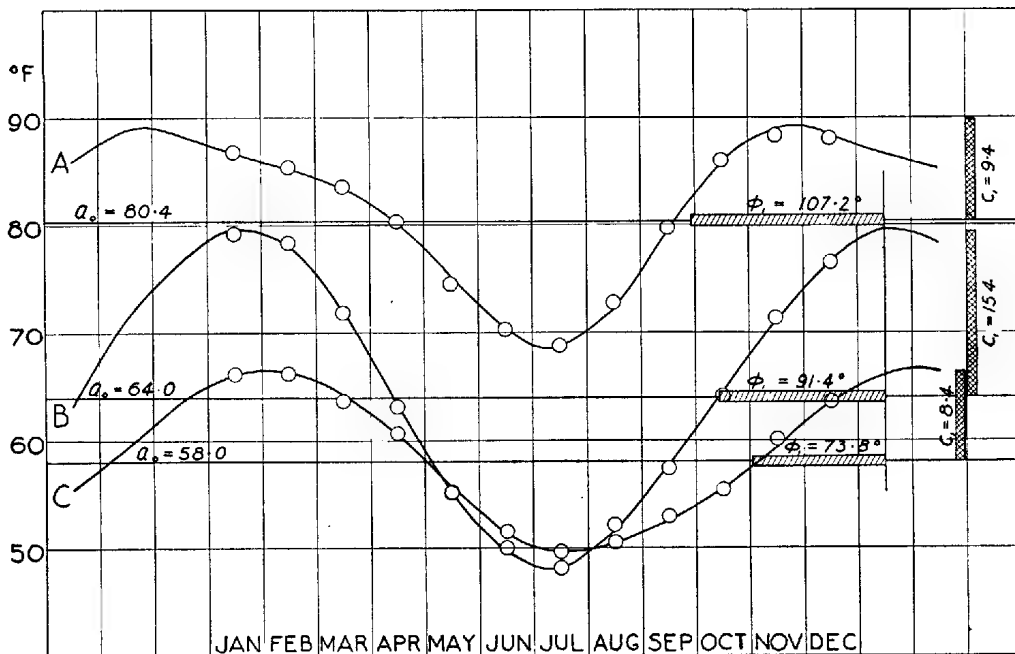


Fig. 1

Illustrating three examples of curves and constants of mean monthly temperatures fitted to a Fourier series of the form:

$$u = a_0 + c_1 (\sin x + \phi_1) + c_2 (\sin 2x + \phi_2) + c_3 (\sin 3x + \phi_3)$$

The circles represent the actual monthly means in each case.

A Daly Waters, N.T.: inland tropical, high mean, small amplitude, early phase.

B Hillston, N.S.W.: continental, large amplitude, medium phase.

C Mount Barker, W. Aust.: oceanic, small amplitude, late phase.

$a_0$  = mean annual temperature.

$c_1$  = amplitude of the first term.

$\phi_1$  = phase angle of the first term, when a value of  $0^\circ$  is given to 15 January.

The amplitudes are readily understood. The magnitude of the phase angle is determined by the point of origin of the curve, in this case 15 January, and represents the distance between the time of intersection of the temperature curve in the spring with the mean value, and 15 January.

If there were no lag between solar radiation and temperature this point of intersection would occur at the spring equinox and the phase angle would have a value of approximately  $116^\circ$ . Actually a value of  $115.6^\circ$  was chosen as this was the phase angle of the curve for solar radiation at the outer limit of the atmosphere

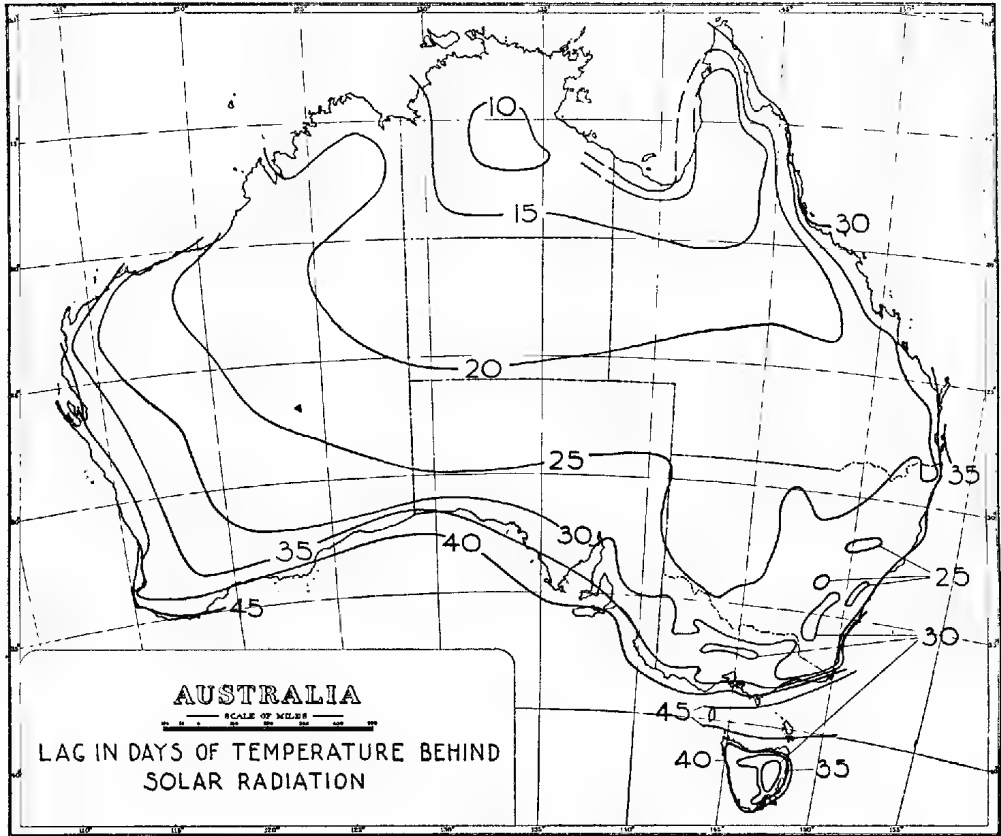


Fig. 2

calculated for the latitude of Adelaide. The lag between temperature and solar radiation which is the form in which the phase is expressed in fig. 2 has been calculated in each case from the equation:

$$\text{Lag in days} = (115.6^\circ - \phi_1) \times \frac{365}{360}$$

Fig. 3 calls for little comment. It may be compared with Griffith Taylor's map (1920) showing the mean temperature range. This range is approximately twice the amplitude. The areas having the greatest amplitude are the central parts of Western Australia and the north-western parts of New South Wales with the adjacent portions of Queensland. Fig. 2, illustrating the lag in phase between the temperature curve and that of solar radiation, is of some considerable interest in that Western Australia is almost unique in having appreciable areas with a lag greater than 40 days. The only other areas are Kangaroo Island, the islands in

Bass Strait and the north coast of Tasmania. This feature may well play an important part in determining the choice of varieties of crops and the quality of these crops. The Karri belt falls mainly within this zone, and there may possibly be some correlation between this characteristic temperature regime and the fact that tobacco of acceptable quality can be grown, for example, at Manjimup.

There appears to be little in the literature on this subject but reference may be made to recent investigations along similar lines by Hopkins (1941), who examined the mean monthly sequence of summer temperatures at three Canadian

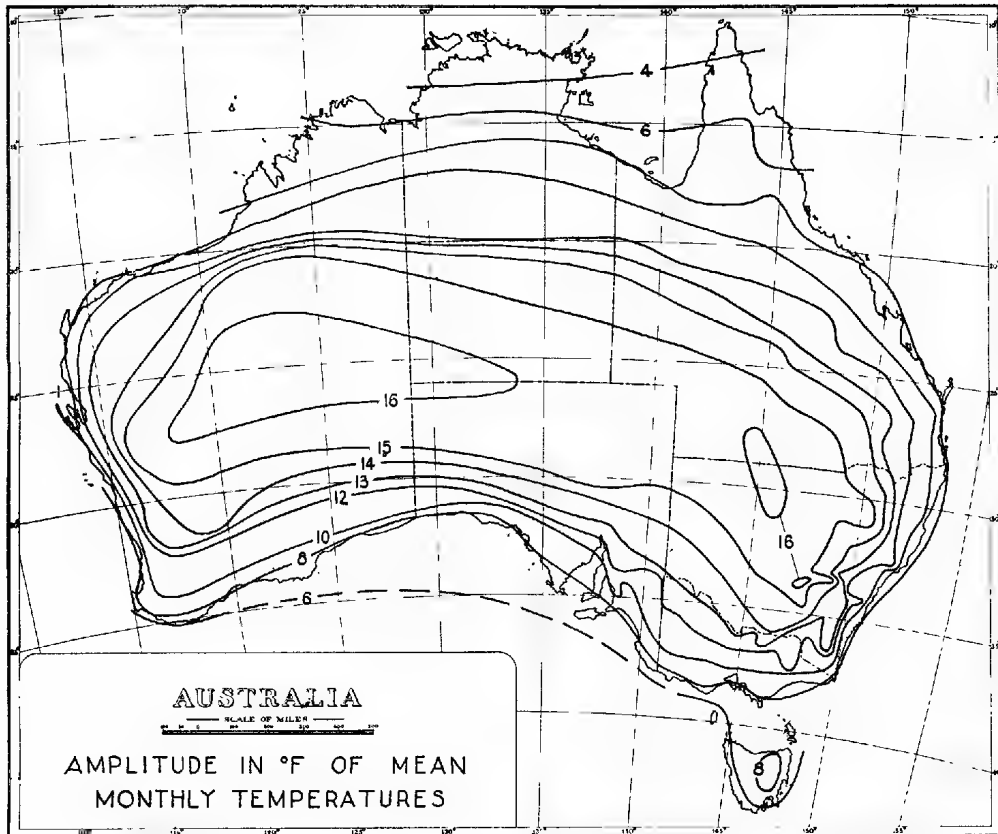


Fig. 3

stations over a period of forty-four years by expressing each annual sequence as an orthogonal polynomial function of time. Differences in "continentality" were found by this method, but no evidence of differences in phase was obtained.

Acknowledgments are due to Miss P. J. Fraser and to Mr. R. A. Priest for assistance in the arithmetical computations.

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# LARVAL TREMATODES FROM AUSTRALIAN FRESHWATER MOLLUSCS PART VIII

By T. HARVEY JOHNSTON and L. MADELINE ANGEL, University of Adelaide

## Summary

*Cercaria metadena* n. sp.

This cercaria was first found at Tailem Bend, Murray River, South Australia, in April 1937. It has been obtained from 15 *Planorbis isingi* from 1 of 22 during April to October 1937; from nil of 10 in 1938; from 14 of 2,751 during February to November 1939 (4 of 237 in February, 8 of 114 in April, 1 of 2,129 in May, 0 in September, 1 of 267 in November); from nil of 34 during 1940; and from nil of 4 during 1941; thus 15 have been found infected amongst 2,821 examined (1·17%). The mollusc has been taken very rarely since November 1939.

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[Read 14 May 1942]

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*Amerianna pyramidata* is the chief host for the larval parasite, though the latter has been found occasionally in *A. tenuistriata* which is a much less common mollusc. Its incidence in *A. pyramidata* was found to be as follows: in 0 of 995 examined in 1937 (April to December); one of 585 in 1938 from March to December (present in May); four of 2,191 in 1939 from February to October (present in February and April); four of 1,303 in 1940 from February to December (present in March and December); 25 of 6,865 in 1941 (present in January, February and December). The total for the period 1937 to 1941, inclusive, was 34 infected *A. pyramidata* in 11,939 examined, i.e., 0.28%. In these totals the less common *A. pectorosa* has been included, but the parasite has not been detected in that species. We have recently found the cercaria issuing from 12 of 127 *A. pyramidata* and *A. tenuistriata* in January 1942, from 6 of 546 in February 1942, and from 1 of 73 in March 1942. The parasite has been observed from December to May, and chiefly in December and January.

## SPOROCYST

The long narrow sporocysts, whose walls contain many orange-yellow refractive granules, resemble those of *Cercaria multicellulata* Miller in being so twisted in the liver of the snail that it is almost impossible to dissect them out unbroken. They apparently disintegrate very readily, even before the liver of the dead host. On the death of the snail the cercariae must soon leave the sporocyst for very few of the latter, whether obtained from snails which had died or from those killed for the purpose, contained any cercariae, there being present only a few bodies which may have been germ balls. An unbroken sporocyst which was dissected out measured 15 mm. long. The free end which, according to Miller's observations (1926) on *C. multicellulata*, projects from the liver, is tapering and bluntly rounded with the most anterior portion translucent and free from pigment granules, as in *C. multicellulata*. A birth pore was not recognised. The diameter of the sporocyst remained constant, being devoid of constrictions such as have been reported for *C. multicellulata*.

## CERCARIA

The usual position of the cercaria in water is that of rest, with the body flexed on itself, the tail stem vertical, and the furcae (by which the animal is suspended) making an angle of 90°-120° with each other. From this resting position it sinks slowly, or it may float passively in currents. It swims, tail first, in short jerky movements, the body and tail stem describing a figure of eight, while the furcae vibrate separately. There is a slight phototropism. Cercariae may live up to 52 hours.

The anterior organ is more or less oval and about  $60\mu$  long by  $28\mu$  in maximum width, with a slight waist-like constriction. The anterior half of the organ is retractile and is closely set with spines, broader at their base and with the apex directed forwards. There are between 40 and 50 spines around the circumference and about 12 along the length, but there is no definite arrangement in rows. The small protrusible cap, through which the mouth opens, is provided with longer spines, about 18 around the circumference and six or seven in the length, but the arrangement is indefinite. This cap is contained usually in the anterior organ, but under pressure becomes alternately protruded and withdrawn. At its base there open the ducts of the penetration glands.

The spines on the general body surface resemble those on the anterior organ, but are much less closely placed, being more densely situated at the anterior end and becoming relatively sparse behind the level of the front border of the second pair of penetration glands.

There is no definite ventral sucker, but between the first and second pairs of gland cells is a small slightly differentiated "anterior cell mass" which probably represents an acetabulum. The "posterior cell mass" lying behind the third pair of gland cells is probably the genital anlage.

The digestive system is usually visible only after intra-vitam staining. There are a long, very narrow prepharynx, wide pharynx and a slender oesophagus which divides into two short, comparatively thick, crura whose walls regularly show the cell outlines (fig. 1).

Laterally from, and level with the posterior ends of, the crura and just anterior to the first pair of gland cells, is a pair of clear rounded or oval structures, probably unpigmented eyespots, as in *Cercaria bessiae* Cort and Brooks. They seem to be joined by a fine transparent line from the midpoint of which there is a short prolongation anteriorly (fig. 1), but we have no suggestion to offer regarding these structures, unless they are optic nerves.

There are three pairs of large granular penetration glands in the posterior half of the body. On each side the middle and posterior glands are close together while the anterior is slightly separated from the middle gland, so that in certain states of extension of the body there appear to be two groups of gland cells. Each cell has a large nucleus near its posterior end. The glands stain deeply with neutral red and with Nile blue sulphate, the latter staining the ducts as well. These staining reactions are similar to those described by Miller (1926, 53) for *C. multicellulata*. The ducts arise from the anterior lateral border of the glands and the three ducts from each side travel forwards together to the anterior organ which they enter near the midline, their termination being at the base of the small protrusible cap already mentioned.

The nervous system was not definitely identified, but staining with neutral red sometimes showed on either side of the prepharynx a mass of tissue which may have been the brain.

The point of union of the anterior and posterior collecting tubes appeared to be in the vicinity of the anterior border of the middle gland cell, just as in *C. multicellulata*. There are almost certainly eight pairs of flame cells in the body, though the presence of several long vibratile flames in the collecting tubes adjacent to the gland cells rendered counting in that region difficult. On each side there is a pair of flame cells in the anterior and posterior regions of the body respectively, as well as two pairs adjacent to the gland cells. There are also two pairs in the tail. The formula is probably  $2 \{ (2 + 2) + (2 + 2 + 2) \}$ . The excretory canal in the tail leaves the bladder by an island of Cort and the furcal branches terminate just in front of the mid-length of the furcae.

In the tail, the furcae are of approximately the same length as the tail stem. There are neither finfolds nor caudal bodies. The main stem bears a few extremely fine sensory hairs visible only under favourable conditions of lighting

The dimensions in  $\mu$  of *C. metadena* from *Amerianna* and *Planorbis*, together with those of related North American Cercariae, are tabulated

	HOST	BODY		TAIL STEM		FURCA	
		LENGTH range	BREADTH ave.	LENGTH range	BREADTH ave.	LENGTH range	ave.
* <i>C. metadena</i> - -	<i>Amerianna pyramidata</i>	200-217	(212)	38-46	(42)	200-250	(234)
	<i>Amerianna tenuistriata</i>	-	-	-	-	29-33	(32)
* <i>C. metadena</i> - -	<i>Planorbis isingi</i>	175-225	(192)	33-50	(39)	167-234	(209)
** <i>C. bessiae</i> - -	<i>Planorbis trivolvis</i>	139-200	(176)	34-46	(37)	246-308	(255)
† <i>C. flexicorpa</i> - -	<i>Helisoma trivolvis</i>	107-182	(159)	19-32	(26)	156-227	(188)
†† <i>C. hamata</i> - -	<i>Planorbis trivolvis</i>	-	(179)	-	(28)	-	(248)
†† <i>C. multicellulata</i> -	<i>Physa gyrina</i>	-	(136)	-	(26)	-	(196)
	<i>Physa magnalacustris</i>	-	-	-	-	-	(24)
† <i>C. physac</i> - -	<i>Physa parkeri</i>	123-162	(143)	31-36	(36)	185-231	(222)
	<i>Physa gyrina</i>	-	-	-	-	28-31	(36)
‡ <i>C. rhabdocaeca</i> -	<i>Planorbis trivolvis</i>	-	(140)	-	(60)	-	(270)‡
		-	-	-	-	-	(200)

‡ = "Tail trunk practically twice as long as body."

\* = Boiling 10% formalin added to equal volume water + cercariae.

\*\* = Killed in hot 5% formalin.

† = "Preserved" (prob. fixed in hot 5% formalin, since Collins mentions this for permanent mounts).

†† = Mounted in Canada balsam.

‡ = State of cercariae, from which measurements taken not mentioned.

and magnification. Along the lateral margins of the stem is a series of small, pale greenish bodies (probably nuclei) which stain with haematoxylin, but, unlike those of *C. multicellulata* (Miller 1926, 52), do not take up neutral red. The margin of the stem appears to be corrugated, apparently marking the boundaries of the cells containing the greenish bodies. The stem and furcae are beset with minute spines like those on the body, but perhaps not so closely arranged.

*C. metadena* is a pharyngeal, longifurcate, monostome cercaria closely related to *C. Posthodiplostomi-minimi* (= *C. multicellulata* Miller) and to the other members of Dubois' (1938, 272) "rhabdocaeca" group (*C. rhabdocaeca* Faust, *C. hamata* Miller, *C. flexicorpa* Collins), as well as to *C. Uvuliferi-ambloplitis* (= *C. bessiae* Cort and Brooks). In describing *C. physae*, Cort and Brooks did not give an account of the excretory system, but in other features the cercaria resembles those just mentioned. The behaviour of all these cercariae in water is similar except that in *C. multicellulata* and *C. physae* the anterior part of the body is not, apparently, bent over to the ventral surface, while in the brief account of *C. rhabdocaeca* this feature is not mentioned. *C. metadena* differs from all those mentioned above in that its short gut is bifid, whereas in the others, with the possible exception of *C. multicellulata*, it is rhabdocoele. *C. metadena* is larger than the others in body dimensions and differs from them all in the ratio of the lengths of the tail stem and furcae, this being approximately 1:1 for *C. metadena*, whereas in the others the stem is definitely longer than each furca. In addition the arrangement of the spines on the anterior organ and the protrusible cap of *C. metadena* appears to be quite different from the other forms, with the possible exception of *C. multicellulata*. *C. metadena* differs from Faust's description of *C. rhabdocaeca* in the ratio of length to breadth, as well as in the shape of the body. Faust, in his description, made no mention regarding the presence or absence of sensory hairs or caudal bodies. Since Cort and Brooks (1928) considered *C. rhabdocaeca* to be the same as *C. hamata*, as Miller (1926) had previously hinted, these various characters cannot be used to differentiate between the species. Our species differs from *C. multicellulata* in the absence of pigmented eyespots, caudal bodies, and furcal finfold; from *C. hamata* in having a shorter tail stem, and in the absence of caudal bodies; from *C. bessiae* in the smaller dimensions of the tail stem, in the greater width of the body in relation to the tail stem, and in the less prominent eyespots (these being unpigmented in both forms); from *C. physae* in the absence of caudal bodies and pigmented eyespots, and in the extent of body spination; and from *C. flexicorpa* in the absence of head gland cells, and in the presence of body spines in the region behind the pharynx.

#### PRECOCIOUS DEVELOPMENT OF THE DIPLOSTOMULUM IN THE SNAIL HOST

A specimen of *Amerianna pyramidata* from which cercariae had ceased to emerge at least a week (probably several weeks) previously, was dissected early in February 1941, in half-normal saline, and almost immediately many diplostomula appeared in the fluid. The liver and adjacent tissues of the snail were found to be packed with sporocysts, and within each of the latter the diplostomula were being forced up and down rapidly by contractions of the sporocyst. Probably as a result of the change in pH, the diplostomula were emitted almost immediately and the sporocysts then lost their uniform diameter, becoming somewhat moniliform. The sporocysts appeared to be similar in form to those which produce cercariae except that they were white, while normal sporocysts contain orange yellow refractive granules. Amongst the hundreds of diplostomula liberated from the sporocysts, no tailed cercaria was found and extremely few immature cercariae were present. Diplostomula remained alive for several days in one-third-normal saline at 40° F. though they died in a few hours at room temperature.



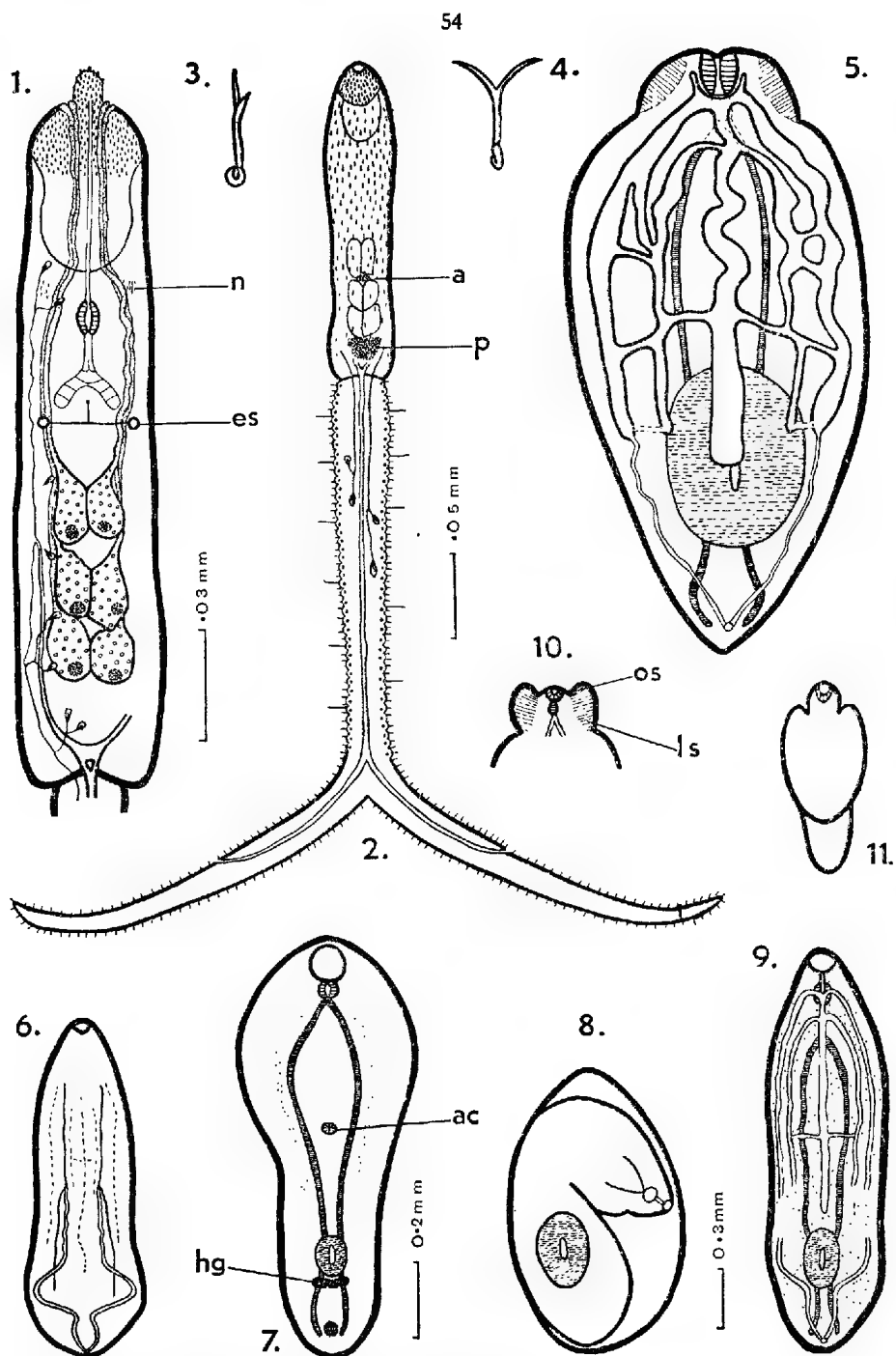


Fig. 1-11

Fig. 1-4, *Cercaria metadena*: 1, drawn from balsam mount, with details from living specimens incorporated; 2, formalinised cercaria (excretory tubes in tail from living specimen); 3, 4, resting position in water. Fig. 5-11, *Diplostomulum metadena* from fish hosts: 5, reserve bladder system (contained concretions not shown), holdfast distorted due to compression; 6, curving arms of bladder; 7, drawn from stained balsam mount; 8, cyst; 10, anterior end of body under compression; 11, freshly excysted specimen. Fig. 5, 6, 9, 10 drawn from compressed specimens, thus showing no differentiation of fore and hind body. Fig. 3, 4, 11 sketches; fig. 5, 7, 10 to same scale; fig. 6, 8, 9, a, anterior cell mass; ac, acetabulum; es, eyespot; hg, holdfast gland; ls, lateral sucker; n, nervous tissue; os, oral sucker; p, posterior cell mass.

Later, in February 1941, a snail (*A. pyramidata*) infected with *C. metadana* was collected at Tailen Bend. It gave off some cercariae for a few days, was not tested during the next two days and died on the following day. Dissection showed that there were thousands of diplostomula throughout the liver and the tissues adjacent to the digestive tract, while others were present in the remaining tissues of the body. Cercariae were entirely absent. Not more than twelve sporocysts, all of which had given off any diplostomes they may have contained, were present. Partly because the diplostomes were not alive when found and partly because of our previous observations on normal sporocysts as well as those referred to in the preceding paragraph, the snail (although its body appeared to be intact) was assumed to have been dead for sufficient length of time to have permitted the disintegration of most of the sporocysts in which the diplostomula must have developed.

We are unable to suggest what factor causes the precocious development of diplostomes in the snail host. It is not associated with lateness in the season, because the occurrences were in midsummer and cercariae (*C. metadana*) had been collected issuing from a snail as late as May (1939). In one case a snail taken in January 1941 emitted very few cercariae during the next 35 days, and then ceased until early March when it liberated two cercariae. Some days later it was killed and dissected, but no trace of sporocysts, cercariae or diplostomula was found. Another snail which had ceased emitting cercariae for some time before its death in early April was found, on dissection, to contain only empty sporocysts. The remaining snail hosts of *C. metadana*, which had been preserved in formalin at death and dissected subsequently, showed no sign of precocious development of diplostomula. Several of them, both *Amerianna* and *Planorbis*, showed no evidence of having been infected, while in most of the *Planorbis* little of the sporocysts remained, though a number of cercariae were still present. These facts indicate: (1) that sporocysts disintegrate readily, (a) on the death of the host, and (b) after a certain period of infection, leaving no evidence of previous infection; and (2) that for some reason, not yet known, developing germ balls may give rise within the sporocyst to diplostomula instead of cercariae.

Cort and Brackett (1937) recorded the precocious development of metacercariae of *Diplostomum flexicaudum* in the snail host, *Stagnicola emarginata angulata* in U.S.A. They found it in 8.6% of 669 snails examined in one month (August). They believed (as we do for *C. metadana*) that in living snails the diplostomula occurred only within the sporocysts; that the presence of diplostomula was associated with old infections; and they recorded that in some cases diplostomula were found in snails which contained very few cercariae and empty sporocysts. They found that these diplostomula were usually considerably smaller than those described by Hughes and Berkhout (1929) as *D. gigas* (which was identified by Van Haitsma in 1931 as *D. flexicaudum*) from the normal habitat of the species, i.e., in the lens of certain fresh-water fish.

Cort and Brackett (1937) believed that *Diplostomulum browni* described by Hughes (1929) from sporocysts as well as from the soft tissues of *Stagnicola*, was the precocious metacercaria of *Diplostomum flexicaudum*. Olivier (1940), by feeding experiments, showed that this suggestion was correct, thus proving that diplostomula which had developed in a snail host not only were normal in appearance, but were infective when fed to a suitable avian host.

We found that formalinized diplostomula from one snail were much smaller than those from another, the range in the former case being: length, 225-334  $\mu$  (average 250), breadth 134-184  $\mu$  (average 167); while in the second they measured: length, 350-585  $\mu$  (average 443), breadth 184-267  $\mu$  (average 212). The specimens had been killed with boiling 10% formalin, and ten were measured in each case.

## DIPLOSTOMULUM STAGE FROM SNAIL HOST

The living diplostomulum was capable of continual change in form, from being broad, flat and leaf-like to become narrow and elongate. Lateral "suckers" were not obvious, though present, the form of the head region depending on the slight degree of protrusion or retraction exhibited by these organs which lay on either side of and closely adjacent to the oval sucker. The latter measured 24 by 25  $\mu$  long. The acetabulum is small 19 by 23  $\mu$  wide, the nuclei (about 24 in number) around its periphery showing clearly after staining. It lies immediately in front of the holdfast (fig. 12, 13, 18). The latter is rather large (53-106  $\mu$ , averaging 76  $\mu$  in diameter), lies mainly in the posterior third of the body and surrounds a narrow slit which enters a wide cavity (fig. 17). Surrounding the slit are many elongate pyriform cells with large nuclei towards the distal ends. The cuticle in this region is provided with spines which, though minute, are more prominent than those on the rest of the body. The holdfast gland lies transversely just behind the holdfast. Under oil immersion magnification the body cuticle is seen to be roughened with what are, perhaps, extremely minute

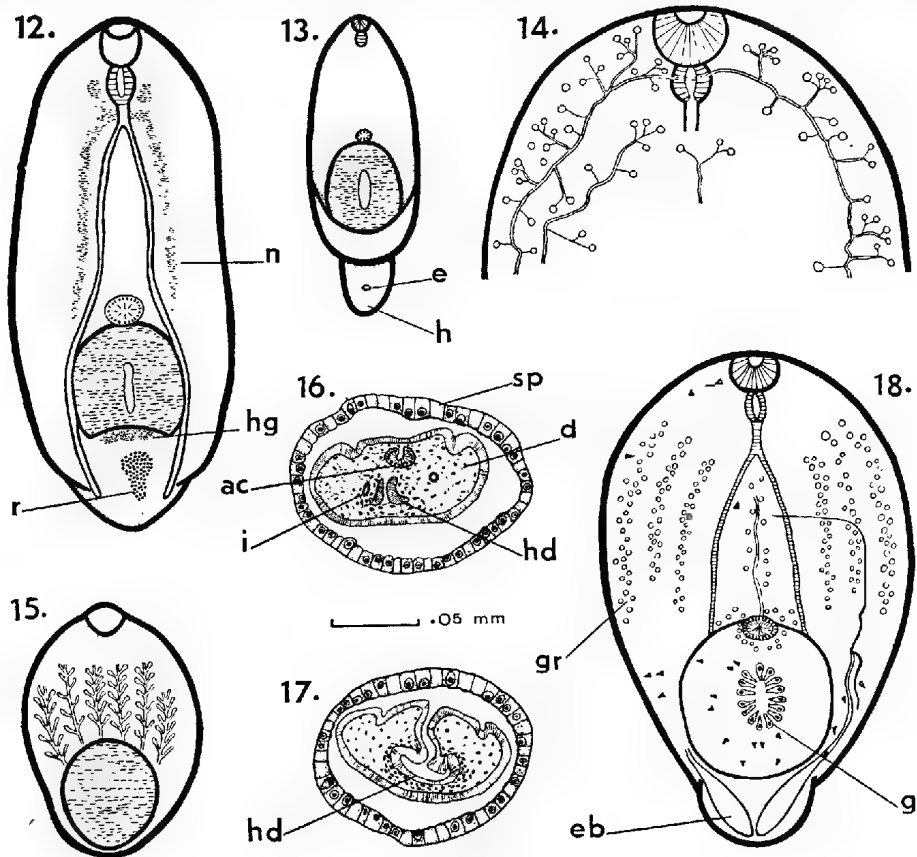


Fig. 12-18

Fig. 12-18, *Diplostomulum metadene* from snail host: 12, drawn from stained balsam mount; 13, uncompressed specimen; 14, arrangement of calcareous corpuscles of secondary system as seen in one individual; 15, sketch (see text); 16, 17, sections through sporocyst containing diplostomes; 18, parts of primary and secondary systems. Fig. 13, 14, 15, 18 sketches drawn from living specimens. Fig. 1, 5, 6 to same scale.

ac, acetabulum; d, diplostome; e, excretory pore; eb, excretory bladder; g, gland cells; gr, excretory granules; h, hindbody; hd, holdfast; hg, holdfast gland; i, intestine; n, nerve cord; r, reproductive anlage; sp, sporocyst wall.

spines. The surface of the body is almost entirely covered with granular cells which stain faintly after treatment with neutral red and orange G.

A prepharynx is absent. The short oesophagus is succeeded by the narrow crura which extend into the hind body; these also stain with neutral red. Two lateral nerve cords are connected by a commissure situated posteriorly to the pharynx.

The main arms of the excretory system converge in the hind body to open dorsally at the excretory pore near the end of the worm. The pattern of the primary excretory system, as far as recognisable, has become more complex than it was in the cercaria. Fig. 18 indicates the position of flame cells seen, but it is obviously not a complete picture of the arrangement, and we were unable to trace the capillaries or any but the main collecting tubules.

The secondary or reserve excretory system showed up best at death, and immediately after. The general plan conformed to the typical strigeid arrangement suggested by van Haitsma (1931) and Bosma (1934, 144). The anterior ends of the original primary bladder which extend far up the body anteriorly are joined by two commissural vessels which in turn connect with a median longitudinal vessel extending from the anterior commissural pair to end blindly somewhere posterior to the acetabulum.

In one favourable specimen was seen on each side a very narrow marginal vessel somewhat like the secondary collecting tubules of a cercaria—and from this arose numerous twig-like branches, which might end in one "follicle," or four or five, each follicle having its own short twig. These structures would, no doubt, correspond to the "terminal tubules with their calcareous corpuscles" of Bosma. Although only the two lateral vessels were seen, the calcareous bodies, which were extremely numerous, appeared to be arranged in seven longitudinal lines. These almost certainly represent the site of excretory canals, the two outer vessels and the median vessel (previously mentioned) which were actually seen, and two more vessels on either side of the median.

In addition to the system of calcareous bodies, there was another system consisting of five or six parallel rows of tubes, extending from the pharyngeal region to the anterior borders of the holdfast organ. On either side each tube gave rise to a number of elongate diverticula arranged like leaves on a flattened branch. Fig. 15 is a sketch illustrating the general arrangement. We do not know whether this system was part of the reticulum of the reserve bladder system, or had a lymphatic or a glandular function.

#### DIPLOSTOMULUM METADENA IN FISH

Experiments showed that *Cercaria metadena* will develop into a diplostomulum in the aquarium fish, *Gambusia affinis* and *Phallocceros caudomaculatus*, but regular attempts to infect gold fish (*Carassius auratus*), rice fish (*Oryzias latipes*) and *Barbus* sp. were unsuccessful. Negative results were also obtained with the yabby, *Cherax destructor*, and with tadpoles of *Limnodynastes* sp., but the last-mentioned were frequently found dead soon after having been placed in contact with cercariae, this suggesting that the latter have a detrimental effect on them. Two *Gambusia* jumped out of their tank some hours after having been subjected to infection, and this was probably caused by irritation during invasion.

Amongst native fish, *Craterocephalus fluviatilis* and *Mugilogobius galweyi* from the Murray swamps at Tailem Bend have been found infected with the diplostomulum.

The diplostomula are found in the subcutaneous tissues of the body as well as in the coelom and pericardium, but not in the eyes. Usually the worm was found free and sometimes actively moving, having presumably escaped from its thin investing cyst which probably breaks down soon after the death of the host. In fish which were examined immediately after having been killed, the parasites

were enclosed, folded once, within a thin ovoid cyst averaging 1 to 1.2 mm. by .52-.58 mm. When released the worms measured little more than the length of the cyst.

The diplostomula from fish have undergone further development than those found precociously produced in snails. They are larger, the average of five specimens in canada balsam being .88 by .3 mm., the largest reaching 1.67 by .5 mm. The region between the acetabulum and the holdfast has lengthened considerably, so that the former, which lies at the anterior border of the holdfast in the snail diplostome is now situated at about the midlength of the worm and separated from the holdfast by a distance approximately equal to the length of the latter.

The following are measurements recorded from a particularly favourable specimen fixed in formalin and examined in glycerine: acetabulum, about 25  $\mu$  long by 20  $\mu$  broad; holdfast, about .12 mm. long by .08 mm. broad (nearly one-fifth of the width of the forebody in this region).

The forebody is about nine times as long as the hindbody. The holdfast lies in the posterior third, or more usually, just within the posterior fourth of the body; its length is between one-seventh and one-eighth of the length of the forebody. The oral sucker is slightly larger than the acetabulum and measures about .036 mm. in diameter. Immediately laterally from it are the lateral pseudo-suckers which may appear as very shallow depressions, and which are readily protrusible in life. They do not appear to possess gland cells, but are marked by fine muscular striations. The region just postero-lateral to them may project as a prominent shoulder, causing the anterior end of the worm to appear somewhat trilobed.

The pharynx is narrower and shorter than the oral sucker. Behind the deeply staining holdfast gland lies the lobed genital rudiment which does not show much differentiation beyond the stage present in the diplostomula from snails.

The five main longitudinal channels of the secondary excretory system are very conspicuous because of their width and contents and can be seen readily through the cyst wall. The median canal extends posteriorly to a point about midway down the length of the holdfast, thence becoming greatly narrowed and less defined, with smaller and more scattered globules. The main canals have become connected by a number of more or less transverse anastomoses (fig. 5). Besides the large channels there are numerous very narrow vessels, with a more or less regular arrangement, extending between the former. The terminal tubules containing calcareous concretions seen in the precociously developed diplostomula were not observed in those from fish. In the region behind and extending posteriorly from the holdfast are very small canals of the secondary system, which communicate with the central stem of the secondary, as well as with the main arms of the primary, system. These canals contain only minute granules.

Some of the stages in the development of the excretory system were recognised. In fig. 6 the arms of the main bladder appear to be bending mesiad (cp. Bosma's plate x, fig. 14). The anterior and posterior collecting tubules of the primary system are still visible, as are various branches which contain calcareous concretions of the reserve system, though the actual connections of this system with the main arms of the bladder were not seen in this specimen. Fig. 9 shows the main branches of the reserve system, and the commissural vessels which mark the first stage of anastomosis. In the specimen figured in fig. 5 the anastomosis has extended further, and this probably represents the young adult stage (cp. Bosma's fig. 18 of the adult system).

#### RELATIONSHIPS

*C. multicellulata* Miller 1923 has been shown by Ferguson (1936; 1937) to be the larva of *Posthodiplostomum minimum* (McCallum). Dubois (1938, 272) stated that *C. rhabdacaeca*, *C. hamata* and *C. flexicorpa* could be considered as larvae of species of *Posthodiplostomum*, though he mentioned (1938, 322) that,

apart from the flame cell formula, *C. bessiae* (larva of *Uvulifer ambloplitis*) possessed all the characters belonging to this group. Cort and Brooks in describing *C. bessiae*, stated that they could not be certain that there were not more than six pairs of flame cells in the body, and it seems to us to be unwise to discriminate between the cercariae of these two genera until the excretory system of the larva of *Uvulifer* has been determined definitely.

The structure of the diplostomulum suggests that it may be the larva of *Bolbophorus*, a species of which occurs in pelicans at Tailern Bend. The position of the pseudo-sucker in relation to the oral sucker, the tendency for "shoulders" to be present, the general relations of the acetabulum and holdfast, and the relative widths of the fore and hind body all point towards such a conclusion. These same features distinguish it from the larva of *Diplostomum*. The differentiation into well-defined fore and hind body distinguishes it from *Hysteromorpha* and the presence of pseudo-suckers allows its separation from most of the remaining diplostome genera.

We have placed eggs of *Bolbophorus* in experimental tanks containing a number of *Amerianna* and *Planorbis*, but none of these snails has subsequently produced cercariae. One *Planorbis*, dissected at death two months after having been subjected to infection, contained about twelve sporocysts, but it was not possible to identify these definitely as those of *C. metadana*. Further experiments will be undertaken when material shall have become available.

We have used the term Diplostomulum as a collective name for the metacercaria stage of species of Diplostomidae. The specific name is based on the posterior position of the gland cells in the cercaria.

We desire to acknowledge generous assistance received from Messrs. G. and F. Jaensch and L. Ellis of Tailern Bend, as well as from the Commonwealth Research grant to the University of Adelaide.

#### SUMMARY

- 1 *Cercaria metadana* n. sp. is described from *Planorbis isingi*, *Amerianna pyramidata* (type host) and *A. tenuistriata* from Tailern Bend, South Australia.
- 2 The percentage infection observed in *Planorbis* was 1.17, and in *Amerianna* spp. 0.28 during 1937-1942.
- 3 The sporocyst, cercaria and diplostomulum are described and the cercaria compared with allied North American species.
- 4 The diplostomulum occurs in some species of native fish, and has been obtained from experimentally infected aquarium fish (*Gambusia* and *Phalloceros*).
- 5 Precocious development of diplostomula in a snail host (*Amerianna*) is reported.
- 6 The adult stage is probably a *Bolbophorus*, a species of which occurs in local pelicans.

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# THE GENUS THYSANOPODA (CRUSTACEA, EUPHAUSIACEA)

By KEITH SHEARD

## Summary

This difficult genus is characterised as follows: In general as in *Euphausia*, but penultimate pair of legs distinctly developed and of the same structure as the preceding; last pair with the endopod obsolete but having a well-developed exopod. All the true gills provided with an interiorly bent branch, the two posterior pairs rather complex in structure, last pair much the larger and richly arborescent. Flagella of both pairs of antennae greatly elongate. Exognath of second pair of maxillae very small. Luminous globules as in *Euphausia*. Genotype *Thysonapoda tricuspida* Milne-Edwards 1830.

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[Read 14 May 1942]

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The main specific characters are to be found in the maxillulae, male copulatory organs, the lappet of the first antennular segment, the presence or absence of lateral denticles on the carapace in the adult, and the presence or absence of teeth or denticles on the midline of posterior margins of the abdominal segments also in the adult.

*Thysanopoda* should be preserved in 70% alcohol. Formalin, the commonly used preservative not only renders examination difficult but is a source of error in these, as in all crustacean specimens.

The genus is of world oceanic distribution. Australian representatives are: *Thysanopoda obtusifrons* Sars, *T. monacantha* Ortmann, *T. tricuspidata* Milne-Edwards and *T. orientalis* Hansen, and *T. johnstoni* n. sp.

## Order EUPHAUSIACEA

### Family EUPHAUSIIDAE

#### Genus THYSANOPODA Milne-Edwards 1830

*Thysanopoda* Milne-Edwards 1830, 451; Sars 1885, 97; Hansen 1905, 12; 1905a, 18; 1910, 81; 1911, 1; 1912, 207.

*Parathysanopoda* Illig 1909, 225.

#### LIST OF SPECIES AND SYNONYMY

##### THYSANOPODA TRICUSPIDATA Milne-Edwards 1830

*Thysanopoda tricuspidata* Milne-Edwards 1830, 451, pl. xix; *tricuspidata* Milne-Edwards 1837, 45, pl. xxvi, fig. 1-6; *tricuspidata* Sars 1885, 98, pl. xvii; Hansen 1910, 82, pl. xii, fig. 3a-3b; 1912, 208, pl. iv, fig. 2a; 1913, 23; 1916, 637; Tattersall 1913, 873; 1924, 14; 1926, 13; 1936, 165 (larvae); 1939, 212; Zimmer 1914, 416; Illig 1930.

*Cyrtopia rostrata* Dana 1852.

##### THYSANOPODA CRISTATA Sars 1883

*Thysanopoda cristata* Sars 1883, 22; 1885, 104-106, pl. xviii, fig. 15-20; Hansen 1911, 15; 1912, 209-212 (larvae 284-287, pl. xii, fig. 1a-1g), pl. iv, fig. 1a-1b; Zimmer 1914, 416; *biproduca* Ortmann 1893, 8, pl. i, fig. 1.

##### THYSANOPODA MONACANTHA Ortmann 1893

*Thysanopoda monacantha* Ortmann 1893, 9, pl. i, fig. 2; Hansen 1912, 212, pl. iv, fig. 3a-3c; 1915, 61; 1916, 638; Zimmer 1914, 417; Tattersall 1926, 14; 1939, 213; Illig 1930, 507, fig.; *agassizi* Ortmann 1894, 99, fig. 1-2; Hansen 1910, 87-89, pl. xiii, fig. 3-g; *lateralis* Hansen 1905, 18-19, fig. 14-19; *ctenophora* Illig 1908, 112-113, fig. 1.



## THYSANOPODA AEQUALIS Hansen 1905

*Thysanopoda aequalis* Hansen 1905a, 18-20; 1910, 84, pl. xii, fig. 4a-4c, pl. xiii, fig. 1a; 1912, 214-215, pl. iv, fig. 4a; 1915, 61-62; 1916 67; Zimmer 1914, 417-418, pl. xxvi, fig. 53-54; Tattersall 1909, 123; 1912, 128; 1924, 15; 1926, 14; 1939, 213; Illig 1930; *obtusifrons* Lo Bianca 1901, 440; Thiele 1905, 452; fig.; Ortmann 1905, 964; *microphthalma* Lo Bianca 1903, 192; *aequalis* var. *latifrons* Colosi 1916, 67.

## THYSANOPODA OBTUSIFRONS Sars 1883

*Thysanopoda obtusifrons* Sars 1883, 21; 1885, 102-104, pl. xviii, fig. 1-14; nec Lo Bianca 1901, 440, and 1903, 192; nec Ortmann 1905, 964; nec Thiele 1905, 452, fig.; Hansen 1910, 15; 1912, 215, pl. iv, fig. 5a-5f; Tattersall 1924, 16; 1939, 213; Zimmer 1914, 419; Chilton 1926, 519; *vulgaris* Hansen 1905, 15; 1905a, 20.

## THYSANOPODA PECTINATA Ortmann 1893

*Thysanopoda pectinata* Ortmann 1893, 10, pl. i, fig. 4; Hansen 1905a, 25; 1912, 218-222, pl. v, fig. 1a-1m; 1915, 62; 1916, 639; Tattersall 1912, 129; 1939, 213; nec Hansen 1905, 20.  
*Parathysanopoda foliifera* Illig 1909, 225; 1930, 510, fig.

## THYSANOPODA ACUTIFRONS Holt and Tattersall 1905

*Thysanopoda acutifrons* Holt and Tattersall 1905, 102, (pars); 1906, 8, pl. i; Tattersall 1925, 6; 1925, 6, pl. ii, fig. 4; 1939, 213; Hansen 1905a, 22; 1910, 85, text fig.; 1912, 218, pl. v, fig. 1a-1m; 1915, 62; Illig 1939; *pectinata* Hansen 1905, 20.

## THYSANOPODA ORIENTALIS Hansen 1910

*Thysanopoda orientalis* Hansen 1910, 222, pl. v, fig. 2a-2c; 1912, 222, pl. v, fig. 2a-2c; 1915, 64-65; 1916, 639; Zimmer 1914, 419; Tattersall 1939, 214; 1936, 166.

## THYSANOPODA MICROPHTHALMA Sars 1885

*Thysanopoda microphthalma* Sars 1885, 106-108, text fig. 3; Hansen 1910, 85, text fig.; Tattersall 1926, 15; nec Lo Bianca, 1905, 192; *distinguenda* Hansen 1905, 17, fig. 13; Holt and Tattersall 1906, 11, pl. ii.

## THYSANOPODA CORNUTA Illig 1905

*Thysanopoda cornuta* Illig 1905, 663-664, fig. 1-3; 1908, 463-464; Hansen 1911, 16; 1912, 223-224; ? 1915, 65-66, 1916, 639; Tattersall 1913, 872; ? 1926, 15-16; 1939, 214 (larvae); Illig 1930, 513; *insignis* Hansen 1905, 19, text fig.

## THYSANOPODA EGREGIA Hansen 1905

*Thysanopoda egregia* Hansen 1905, 22, text fig.; 1912, 225; Illig 1908, 463; ? *megalops* Illig 1908, 54, fig. 1 and 2; 1911, 45-46, fig.

## THYSANOPODA MANSUII Marukawa 1928

*Thysanopoda mansuii* Marukawa 1928, 23.

## THYSANOPODA ARMATA Marukawa 1928

*Thysanopoda armata* Marukawa 1928, 23.

## THYSANOPODA SPINULA Macdonald 1929

*Thysanopoda spinula* Macdonald 1929, 63.

The genus has been divided by Hansen (1912, 206) into two well-marked sections.

GROUP A: Carapace without any distinct cervical groove. Maxillula with the pseudexopod moderately large to very large, at least half its length situated beyond the outer margin of third joint, palp at most moderately long and somewhat over-reaching the third joint. Sixth abdominal segment longer than the fifth.

This section may again be divided.

- (1) The carapace in the adult with a denticle on or near the lower margins near their posterior end.

*T. tricuspidata* Milne-Edwards; *cristata* Sars; *monacantha* Ortmann (= ? *agassizi* Ortmann); *aequalis* Hansen; *obtusifrons* Sars.

- (2) Carapace in the adult without denticles on the lower margins near their ends.

*T. microphthalma* Sars; *pectinata* Ortmann; *orientalis* Hansen; *acutifrons* Holt and Tattersall; *johnstoni* n. sp.

GROUP B: Carapace with a well-developed cervical groove. Maxillula with the pseudexopod somewhat small, scarcely or not at all over-reaching the outer margin of the third joint, palp very long. Sixth abdominal segment shorter than the fifth.

*T. cornuta* Illig and *T. egregia* Hansen.

I am unable to obtain descriptions of *T. mansuii* and *T. armata* erected by Marakawa 1928, or of *T. spinula* Macdonald 1929.

In Group A, section 1, separation is difficult. *T. tricuspidata* Milne-Edwards possesses two denticles on or near the lower margin of the carapace, and the male of *T. aequalis* Hansen lacks the spine-shaped process ( $p^1$ ) on the copulatory organs. The remaining three species can be separated by small differences in the copulatory organs and by differences in the frontal plate, antennular lappet and the dorsal armature of the abdomen. The species are good. Careful reference must be made to the appropriate descriptions and figures.

The species of Group A, section 2, may be separated as follows:

Adult males and females—

- |      |  |                               |
|------|--|-------------------------------|
| (a)  | Antennular lappet multidigitate .. .. .  | <i>T. pectinata</i> Ortmann   |
| (aa) | " " not multidigitate.   |                               |
| (b)  | Abdominal segments 4 and 5 slightly acuminate mesially on postero-dorsal margin.   |                               |
| (c)  | Antennal scale reaching to end of second segment ..                                | <i>T. microphthalma</i> Sars. |
| (cc) | Antennal scale reaching beyond the end of the second joint                         | <i>T. orientalis</i> Hansen   |
| (bb) | Abdominal segments 4 and 5 smooth on the postero-dorsal margin.                    |                               |
| (d)  | Abdominal side plates 1-2-3-4 slightly indented on the lower margin .. .. .        | <i>T. acutifrons</i> H. & T.  |
| (dd) | Abdominal side plate 1 not indented, 2-3-4 deeply indented on lower margin .. .. . | <i>T. johnstoni</i> n. sp.    |

Adult males. Copulatory organs—

- |      |   |                               |
|------|---|-------------------------------|
| (a)  | Spine-shaped process absent .. .. .                                       | <i>T. johnstoni</i> n. sp.    |
| (aa) | Spine-shaped process ( $p^1$ ) present.                                   |                               |
| (b)  | Terminal process ( $p^2$ ) saw-toothed behind the terminal margin .. .. . | <i>T. microphthalma</i> Sars. |
| (bb) | Terminal process not toothed.   |                               |
| (c)  | Terminal process longer than the proximal process ( $p^3$ )               | <i>T. pectinata</i> Ortmann   |
| (cc) | Terminal process shorter than the proximal.                               |                               |
| (d)  | Terminal process evenly rounded at distal end .. .. .                     | <i>T. orientalis</i> Hansen   |
|      | " " acutely pointed at distal end .. .. .                                 | <i>T. acutifrons</i> H. & T.  |

*T. aequalis* Hansen and *T. johnstoni* n. sp., although in different sections of the genus, are peculiar amongst the *Thysanopoda* in lacking the spine-shaped process of the copulatory organ.

## Group B—

- (a) Rostral plate slightly up-curved, tip surmounted by a small tubercle .. *T. cornuta* Illig.  
 (aa) Rostral plate down-curved, no rostral tubercle present .. *T. egregia* Hansen

***Thysanopoda johnstoni* n. sp.**

B.A.N.Z.A.R.E. sta. 111 (44° 11' S., 143° 36' E.) N200, 1,710-0 m., 17 March 1931, surface temperature 12·00°, surface salinity 34·56, 2 ♀♀ 39 mm., 1 ♂ 33 mm. "Warreen" sta. 25/38 (37° 14' S., 150° 23' E.) N70, 500-250 m., 14 August 1938, surface temperature 14·90°, surface salinity 35·50, temperature at 300 m. 11·55°, salinity at 300 m. 35·06, three damaged specimens. Investigator Straits, from stomach of Southern Blue-fin Tuna (*Thunnus maccoyi* Castelnau), one adult.

This species falls into Hansen's group A, section 2, possessing the characteristic maxillula, the sixth abdominal segment longer than the fifth and having neither a cervical groove, nor a denticle on the lower margin of the carapace.

The eyes are small, rounded and brown in spirit specimens, with the produced frontal plate barely protruding beyond them.

The antennule has the first segment the longest, furnished with a lappet similar to that of *T. acutifrons* H. & T. but longer, reaching to the middle of the second segment. The third antennular segment terminates in a small setose lappet.

The antennal squama, fringed with long setae along its curved inner margin and on its slightly curved distal end reaches to a little more than half-way up the third antennular segment. The spiniform outer process from the sub-basal joint is thin and tapering, as long as the breadth of the squama.

In the maxilla the distal segment is ovate, slightly longer than the preceding.

The maxillula resembles that of *T. pectinata* Ortmann but the pseudexopod is narrower and the palp relatively longer. Both the maxilla and maxillula are heavily setose with plumose setae. The abdominal segments are without trace of any denticles dorsally. The side plates of abdominal segments 1 to 5 resemble those of *T. microphthalmus*, figured by Holt and Tattersall (1906, pl. ii) as *T. distinguenda*. However the emargination of the lower border of plates 2, 3, and 4 is much greater than for that species.

The preanal spine is well developed and is simple in both male and female.

The endopod and exopod of the uropods are both slightly longer than the telson, which bears four pairs of dorsal denticles.

The copulatory organs are distinctive. The spine-shaped process is absent. The terminal process, about half the length of the proximal, is sickle-shaped at its distal third, but from the bulb of the commencement of the sickle, a flat membrane runs nearly to the tip. At its distal end this membrane bears, on the outer margin, two very small, rounded prolongations.

The proximal process is somewhat of the form figured for *T. orientalis* by Hansen (1912).

The median lobe resembles that of *T. pectinata* figured by Hansen (1912), but the additional process is not hooked, while there are two secondary additional processes. In all the median lobe bears four processes instead of the three normal to the genus.

A subadult female (length, 15 mm.) does not possess a lateral denticle on the carapace.

This species is named in honour of Professor T. Harvey Johnston, Biologist to the B.A.N.Z.A.R.E. and Editor of the Expedition's reports.

Thanks are due to the B.A.N.Z.A.R.E. committee for permission to publish this preliminary description of the species, which will be more fully dealt with in a

forthcoming paper on the Euphausiacea of the Expedition; and also to Dr. H. Thompson of the Division of Fisheries, Council for Scientific and Industrial Research of Australia, for the use of the "Warreen" material.

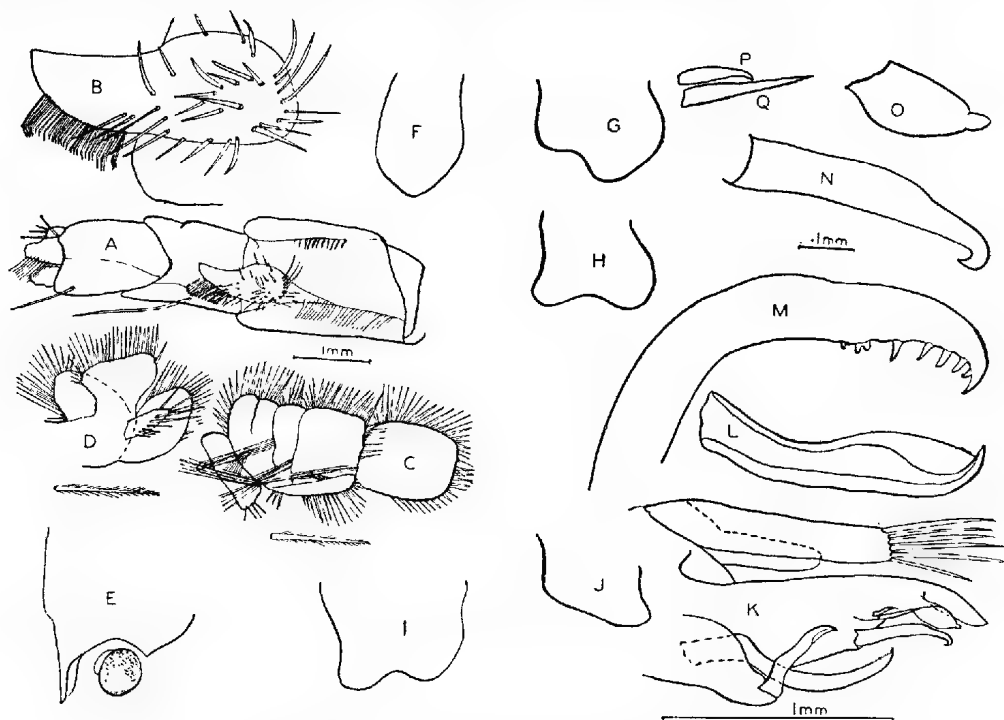


Fig. A-Q *Thysanopoda johnstoni* n. sp.

A, antennular peduncle; B, antennular lappet; C, maxilliped; D, maxillula; E, frontal plate; F-J, abdominal side plates 1-5; K, copulatory organ; L, terminal process ( $p^2$ ); M, tip of proximal process ( $p^3$ ); N, lateral process ( $p^4$ ); O, additional process ( $p^5$ ); P-Q, secondary additional processes ( $p^6, p^7$ ).

#### THYSANOPODA LARVAE

While no *Thysanopoda* larvae have been definitely correlated with the adults by breeding experiments, it is fairly certain that, by (1) a process of elimination, and (2) comparison of forms gradually approaching an identifiable stage, the larvae of several species have been identified.

The larvae of *T. acutifrons* have been recorded by Frost (Proc. Roy. Irish Acad., 45, B, No. 13) and of *T. tricuspidata* by Sars (1885) and Tattersall (1936). Other larvae belonging to the genus, if not to the ascribed species, are:

*T. agassizi* Hansen 1910; *T. orientalis* of Hansen 1910; *T. aequalis*, *obtusifrons* and *pectinata* of Hansen 1912.

There appears little possibility of working out any scheme whereby conclusive specific identifications of single stages of Euphausiid larvae can be made, although generic separations are possible following on a working knowledge of the group. It is extremely difficult to reduce this knowledge to exact definition. Keys based on the emergence of pleopods are unsound guides. For example, the examination of plankton secured by the "Warreen" over a period of four years along the Southern and Eastern coastline of Australia shows enormous numbers of larvae which can certainly be referred to the genus *Nyctiphanes* and which present, over all, every form of pleopod emergence with no one form dominant over the whole area, although at certain times in certain areas one form or the other may be statistically dominant.

It is extremely likely that particular minor phases of development which may be passed through are as much expressions of the available food supply as of anything else.

Opinions on the significance of minor developmental stages in the Euphausiid larvae have changed from the purely schematic (Lebour 1926, Jour. Mar. Biol. Assoc., U.K., N.S., 14) to a consideration of dominant stages (Fraser 1936, Discovery Reports 14). A wider view has been taken by Rustad (Norske Vidensk. Ak., Oslo, 1930, 1 (5)) who, as the result of work done by the Norwegian Antarctic Expedition of 1927-1928 et seq., endeavours to consider the organism as a whole and discards the idea of a schematised development beyond the very early stages.

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# **NEMATODES FROM AUSTRALIAN ALBATROSSES AND PETRELS**

By T. HARVEY JOHNSTON and PATRICIA M. MAWSON, University of Adelaide

## **Summary**

The collection, which is now being reported on has been assembled during the past thirty-three years, mainly from birds washed ashore after gales. Many of the hosts were sent from the South Australian Museum by the late Director, E. R. Waite, and the present Director, H. M. Hale, to the senior author for examination, the birds having been obtained by Messrs. E. R. Waite, J. Sutton, H. Condon or B. C. Cotton. Mr. Condon has been assiduous in patrolling the local beaches, especially Sellicks Beach, after storms in order to obtain sea birds for the Museum collection and is responsible for many of the host identifications. Prof. Cleland supplied material from Encounter Bay. The Director of the Australian Museum, Sydney, sent some parasites from New South Wales for identification. We desire to thank those who have assisted us, and to acknowledge indebtedness to the Commonwealth Research Grant to the University of Adelaide.

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[Read 11 June 1942]

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The types of the new species now described, with the exception of *Contracaecum pelagicum*, have been deposited in the South Australian Museum, Adelaide. The types and other material of *C. pelagicum* are in the Australian Museum, Sydney.

The only nematodes previously recorded from Australian petrels were: (1) *Seuratia shipleyi* from the Cape pigeon, *Daption capense*, from New South Wales (Johnston 1912), and (2) *S. marina*, described by us (1941) from *Pelagodroma marina*, collected by Prof. Cleland on Flinders Island, Bass Strait. Johnston (1937) recorded *Anisakis diomedae* as having been taken from *Diomedea exulans* off south-western Tasmania (44° 30' S., 141° E.). Stossich (in Shipley 1900) identified *Gnathostoma shipleyi* (= *Seuratia shipleyi*) from *D. exulans* taken off New Britain by Willey.

The following is a list of parasites identified, recorded under their hosts:

- DIOMEDEA EXULANS Linn.—Port Jackson, N.S.W.: *Paryseria diomedae* n. sp., *Anisakis* sp. (immature), *Seuratia shipleyi* (Stoss.). Tasmanian Seas: *Anisakis diomedae* (Linst.).
- DIOMEDEA CHIRYSOSTOMA Forst.—Sellicks Beach, S. Aust.: *Paryseria diomedae* n. sp., *Paryseria macronectes* n. sp., *Anisakis diomedae* (Linst.), *Anisakis* sp.
- DIOMEDEA MELANOPHIS Temm.—Brighton, S. Aust.: *Anisakis* sp. (immature), *Seuratia shipleyi* (Stoss.). Sellicks Beach, S. Aust.: *Paryseria diomedae* n. sp., *Anisakis diomedae* (Linst.). Broken Bay, N.S.W.: *Anisakis diomedae*, *Contracaecum pelagicum* n. sp.
- DIOMEDEA CHLORORHYNCHA Gmel.—Sellicks Beach, S. Aust.: *Anisakis diomedae* (Linst.). Port Adelaide, S. Aust.: *Tetrameres diomedae* n. sp., *Seuratia shipleyi* (Stoss.). Broken Bay, N.S.W.: *Contracaecum pelagicum* n. sp.
- DIOMEDEA CAUTA Gould—Brighton, S. Aust.: *Anisakis diomedae* (Linst.), *Contracaecum magnicollare* Jnstn. and Mawson.
- MACRONECTES GIGANTEUS Gmel.—Brighton, S. Aust.: *Anisakis diomedae* (Linst.), *Anisakis* sp., *Paryseria macronectes* n. sp., *Seuratia shipleyi* (Stoss.). Port Adelaide, S. Aust.: *Anisakis diomedae*, *Anisakis* sp., *Phocascaris* sp., *Paryseria macronectes* n. sp., *Seuratia shipleyi*. Sellicks Beach, S. Aust.: *Seuratia shipleyi*, *Phocascaris* sp., *Anisakis diomedae*, *Anisakis* sp.
- DAPTION CAPENSE Linn.—Encounter Bay, S. Aust.: *Anisakis diomedae*, *Anisakis* sp., *Seuratia shipleyi*.

PACHYPTILA VITTATA Gmel.—Sellicks Beach, S. Aust.: *Scuratia shipleyi*, *Paryseria pachyptilae* n. sp.

PTERODROMA LESSONI Garnot—Encounter Bay, S. Aust.: *Anisakis* sp.

PELAGODROMA MARINA Lath.—Reevesby Island, S. Aust.: *Scuratia marina*.

#### ANISAKIS DIOMEDEAE (Linst.) Yorke and Maplestone

Immature females from *Diomedea chrysostoma* and *D. melanophris* (Sellicks Beach, S. Aust.); *D. cauta* (Brighton, S. Aust.); *D. exulans* (Tasmanian Seas); *Macronectes giganteus* (Brighton, Sellicks Beach, Encounter Bay and Port Adelaide); and from *Daption capense* (Encounter Bay). The species is characterised by the prominent toothed bilobed anterior projections on the lips, the large labial papillae, the prominent cervical papillae lying behind the nerve ring, the short conical tail, and also by the relative lengths of the oesophagus, ventriculus and body. A more detailed account will appear in the report on the parasitic nematodes collected by the British, Australian and New Zealand Antarctic Research Expedition.

#### ANISAKIS sp. (immature)

From *Diomedea exulans* (New South Wales coast); *D. melanophris* (Brighton, South Australia); *D. chrysostoma* (Sellicks Beach); *D. cauta* (Brighton); *Macronectes giganteus* (Brighton, Sellicks Beach, Port Adelaide); *Daption capense* (Encounter Bay); and *Pterodroma lessoni* (Encounter Bay).

Larvae 15-20 mm. long, .4 mm. wide; with three low lips, well developed larval tooth; oesophagus 2.7 mm. long, including ventriculus .48 mm. long, oesophagus one-sixth body length; nerve ring at .25 mm., and cervical papillae at .42 mm. from anterior end of body. Tail .1 mm. long, rounded, with small pointed tip.

Some of these larvae were exsheathing; others which were rather narrower, were still coiled; while others appeared to be older since the form of the lips was more definite. In some cases the three stages occurred in the same host, and in company with them were more mature worms identifiable as *A. diomedae*. If all these larvae belong to the latter species, then it appears that the parasites enter the bird as fine coiled worms and that their main subsequent growth is in thickness.

#### CONTRACAECUM MAGNICOLLARE Johnston and Mawson

A male and two females whose general appearance and measurements agree with those of *C. magnicollare* (originally described in 1941 from the noddy, *Anous stolidus*, from the Great Barrier Reef) were taken from *Diomedea cauta* from Brighton, South Australia.

#### *Contracaecum pelagicum* n. sp.

Fig. 1-3

From *Diomedea melanophris* (type host) and *D. chlororhyncha*, both from Broken Bay, New South Wales (coll. Australian Museum, Sydney). Those from *D. chlororhyncha* are smaller than those from the type host.

Male 30-33 mm., females 35-38 mm. Head narrower than succeeding part of body; distinct annulate collar. Each lip with marked rounded antero-lateral projections, each projection bearing a distinct tooth. Interlabia bifid at tips in all specimens, the bifurcation being as long as one-third the length of the interlabia in some cases, and the amount of bifurcation not necessarily the same on all three interlabia of one specimen; interlabia generally short, conical, sometimes tapering markedly towards tip. Oesophagus 1:10 to 1:13 of body length; oesophageal appendix 1:3.3 and intestinal caecum 1:1.5 of oesophageal length.

*Male*—Spicules 1:6.5 of body length. Tail .18 mm. long, ending in point. Six pairs postanal and numerous pairs preanal papillae, latter arranged in longitudinal row on each side.



*Female*—Tail conical, .32 mm. long. Vulva at about one-third body length from head. Eggs 40-50  $\mu$  by 70-80  $\mu$ .

The species is distinguished from others of the genus by the presence of two teeth on each lip. The shape of the tail and the number of caudal papillae in the male differentiate it from *C. Scotti* (Leiper and Atkinson) from *Diomedea melanophris*.

PHOCASCARIS sp. larvae

Fig. 4

Several immature females were taken from *Macronectes giganteus* (Sellicks Beach and Port Adelaide). Length 5 mm.; head 70  $\mu$  diameter; three lips, with non-denticulate ridges; interlabia absent. Oesophagus .95 mm. long, appendix .5 mm., intestinal caecum .7 mm. Nerve ring .25 mm. from head end. Tail conical, pointed, .14 mm. long.

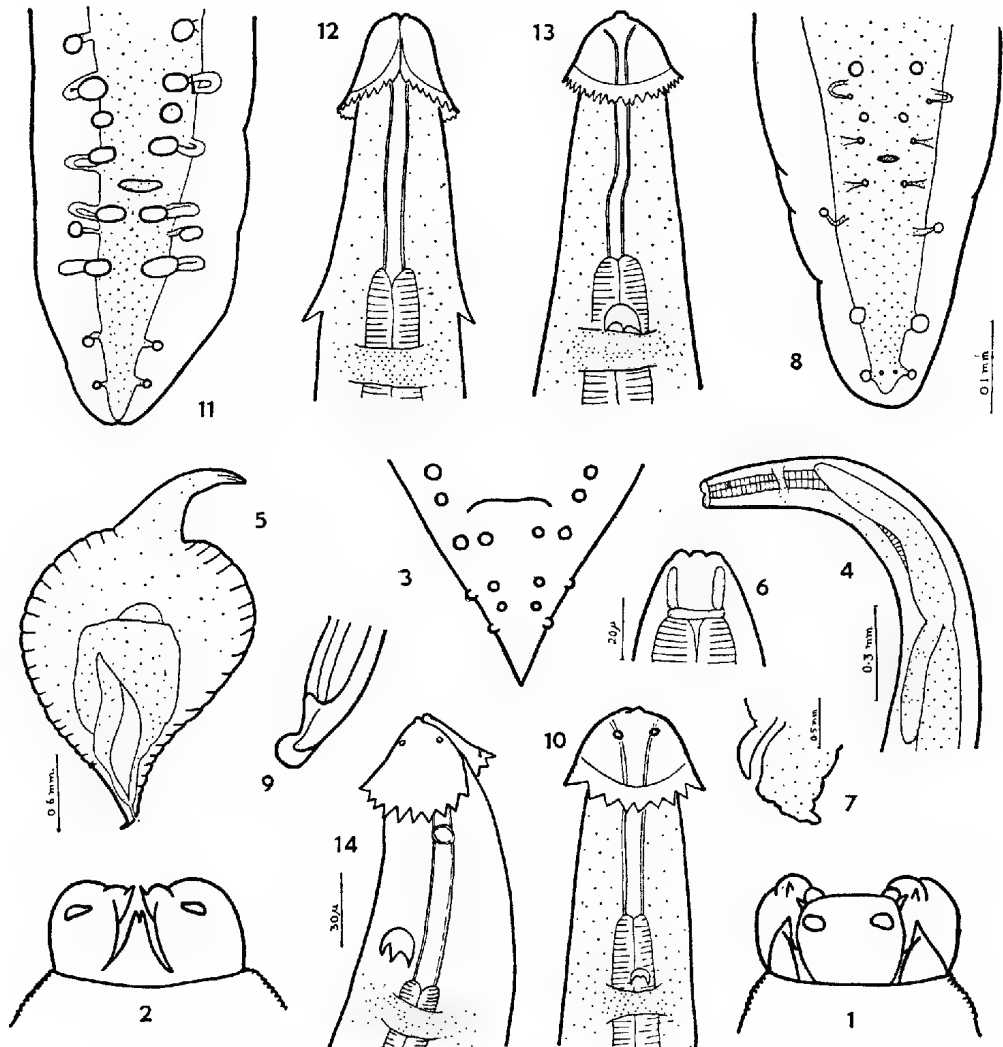


Fig. 1-3, *Contracaecum pelagicum*: 1, dorsal; 2, lateral view of head; 3, male tail, ventral. Fig. 4, *Phocascaris* sp., anterior end. Fig. 5-7, *Tetrameres diomedae*: 5, entire worm; 6, head; 7, female tail. Fig. 8-9, *Seuratia shipleyi*: 8, male tail; 9, tip of shorter spicule. Fig. 10-11, *Paryseria diomedae*: 10, anterior end; 11, male tail. Fig. 12-13, *Paryseria macronectes*, lateral and ventral views of anterior end. Fig. 14, *Paryseria pachyptilae*, anterior end. Fig. 1, 2, 3, and 8 to same scale; 6, 9, and 14; 10, 11, 12, and 13.

**Tetrameres diomedae n. sp**

Fig. 5-7

One female from proventriculus of *Diomedea chlororhyncha* (Port Adelaide). Length 3.2 mm., maximum breadth (under cover-slip) 1.8 mm., is in front of mid-length. Anterior end tapering; head truncated with six small lips; buccal capsule well chitinized, 20  $\mu$  external diameter, 12  $\mu$  internal diameter, 15  $\mu$  long. Nerve ring .12 mm. from anterior end. Vulva .15 mm. and anus .8 mm. in front of tip of tail. Internal structure obscured, even after clearing in creosote.

The only species of *Tetrameres* known from an albatross is *T. certa* (Leidy 1886, syn. *Filaria dubia* Leidy 1856, nec Creplin 1846) from *Diomedea exulans* from the South Atlantic. Leidy's account is inadequate and, since our form is much smaller, it is advisable to regard *T. diomedae* as distinct.

**SEURATIA SHIPLEYI (Stossich)**

Fig. 8-9

From *Diomedea exulans* (New South Wales), *D. chlororhyncha* (Port Adelaide), *D. melanophris* (Brighton, South Australia), *Daption capense* (Encounter Bay), *Macronectes giganteus* (Brighton, Port Adelaide, Sellicks Beach) and *Pachyptila vittata* (Sellicks Beach).

Our specimens agree generally with the descriptions given by Stossich (in Shipley 1900) and by Seurat (1916). In those points in which these two investigators differed, e.g., size of cervical papillae, proportions of the vestibule, and form of the collar (differences which are evident in the figures given by these authors), our material agrees with Seurat's account. Seurat examined only females, while Stossich had both sexes. A lateral view of the male tail in our material agrees with that figured by Stossich, but in ventral view (which was not illustrated by him) definite alae can be seen and there is an extra pair of papillae near the tip of the tail. The terminal multicuspidate papilla does not show up distinctly in ventral view, but, when seen in lateral view, it resembles that figured by Stossich.

The spicules differ in shape and are very unequal, one being .9 mm. long, cylindrical and tapering; the other .23 mm. long, stout, trough-like, with incurving alae on the distal half and with the sides of the trough uniting near its tip to form a prow-like structure, and with the extreme tip bearing a ball-like thickening, just as figured by Stossich who did not indicate the length of the spicules. Eggs are 30  $\mu$  by 15  $\mu$ .

**SEURATIA MARINA Johnston and Mawson**

This species was described by us recently (1941) from *Pelagodroma marina* from Flinders Island, Bass Strait. We now record it from the same host species from Reevesby Island, Spencer Gulf, South Australia.

**Paryseria diomedae n. sp.**

Fig. 10-11

Females from *Diomedea exulans* (type host) from Port Jackson, New South Wales; a complete male from *D. melanophris* and a damaged male from *D. chrysostoma*, both from Sellicks Beach, South Australia.

*Female*—11-12 mm. long; anterior end rounded, with two pointed lips, each with two papillae. Denticulate collar of two lateral lobes each with about nine or ten spines. Mouth leading to vestibule .14 mm. long, 10  $\mu$  diameter. Anterior part of oesophagus .1 mm. long, constricted where nerve ring surrounds it .2 mm. from head; posterior part 3 mm. long. Cervical papillae tridentate, with middle tooth of each shorter than the other two. Tail .16 mm. long, tapering to rounded tip. Vulva 7 mm. from head. Eggs thick-shelled, 40-43  $\mu$  by 20-21  $\mu$ .

*Male* (from *D. melanophris*)—7.7 mm. long. Anterior end agreeing generally with that of female. Vestibule .11 mm. long; anterior part of oesophagus .8 mm. long, termination of posterior part not seen. Spicules 1.2 mm. and .09 mm. long. Tail .17 mm. long with wide caudal alae .35 mm. long. Four pairs precloacal and five pairs postcloacal pedunculate papillae; counting from the most anterior of these, the second, fourth, fifth and seventh have very long peduncles which are twisted in such a way that, in ventral view, the tip appears above its origin from the hypodermis.

The species differs from the genotype, *P. adeliae* Johnston 1937, in the shape and position of the cervical papillae, the number of spines on the collar, and the size of the body.

***Paryseria macronectes* n. sp.**

Fig. 12-13

From *Macronectes giganteus* (type host) from Brighton, South Australia, and *Diomedea chrysostoma* from Sellicks Beach, South Australia. Females only present; 12-15.5 mm. long. Collar with about 18-20 serrations. Cervical papillae .23 mm. from anterior end, tridentate with the three cusps of approximately equal length. Nerve ring .25 mm. from anterior end. Vestibule .17-.18 mm. long, 10  $\mu$  wide; anterior part of oesophagus .62-.7 mm. long, posterior part about 2 mm. Vulva 7.9-8.1 mm. from head. Tail .2 mm. long, blunt-tipped. Eggs 40  $\mu$  by 20  $\mu$ .

The species differs from *P. diomedea* in the length of the vestibule and in the number of serrations on the collar.

***Paryseria pachyptilae* n. sp.**

Fig. 14

One immature female was taken from *Pachyptila vittata* from Sellicks Beach, South Australia. The number of spines in the collar, and the position of the cervical papillae in relation to the posterior end of the vestibule, do not agree with any of the three known species of the genus, so, in spite of the inadequacy of the description we have erected a new species:

Length 10.5 mm. Lips each with an anterior projection and two papillae. Collar with about 13 to 15 large serrations on each side. Cervical papillae 90  $\mu$  from anterior end, each with three equal teeth. Vestibule .11 mm. long, with an S-shaped bend about its mid-length (this is not regarded as likely to be typical of the species). Oesophagus 1 mm. long, not obviously divided into two parts, but widening distinctly posteriorly. Nerve ring surrounding anterior end of oesophagus. Tail rounded, 90  $\mu$  long. Reproductive organs immature and vulva not seen.

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# **SOME AVIAN NEMATODES FROM TAILEM BEND, SOUTH AUSTRALIA**

By T. HARVEY JOHNSTON and PATRICIA M. MAWSON, University of Adelaide

## **Summary**

All of the material described below was collected at Tailem Bend, South Australia. Many of the parasites taken had been recorded previously, and only new hosts or species are listed below. The hosts were collected by Messrs. G. and F. Jaensch and L. Ellis, to whom we are indebted for help. The work was made possible by the Commonwealth Research Grant to the University of Adelaide. New records and species are as follows:

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QUERQUEDULA GIBBERIFRONS Muller—*Echinuria querquedulae* n. sp., *Ephomiodiostomum uncinatum* (Lundahl), *Streptocara* sp.

MICROCARBO MELANOLEUCUS Vieill.—*Streptocara recta* (Linst.), *Synhimantus* sp.

CHLIDONIAS LEUCOPAREIA Temm.—*Streptocara recta* (Linst.).

PELECANUS CONSPICILLATUS Temm.—*Tetrameres pelecani* n. sp., *Phocascaris* sp.

LEIPOA OCELLATA Gould—*Leiponema ellisi* n. g., n. sp.

***Echinuria querquedulae* n. sp.**

Fig. 1

From the grey teal, *Querquedula gibberifrons*. The material consists only of a female 4.2 mm. long; it is, however, mature, as it is distended with eggs ready for deposition. Lips very shallow, each with two papillae and a large anterior projection. Cords 4.1 mm. long, not recurrent, each apparently formed of a double row of minute plates. Cervical papillae not seen. Four rows of hooks on body, beginning at level of posterior end of vestibule and extending to level of anus; in region of cords all four rows are on dorsal surface of body. Excretory pore .36 mm. from head. Vestibule 100  $\mu$  long; its anterior 30  $\mu$  cup-shaped, 18  $\mu$  wide; posterior 70  $\mu$  cylindrical, 11  $\mu$  wide. Anterior part of oesophagus .4 mm. long, posterior part 1.36 mm. Tail tapering, 44  $\mu$  long. Vulva .36 mm. from posterior end, eggs 20-21  $\mu$  by 32-33  $\mu$ , thick-shelled, containing embryos.

The specimen in general features closely resembles *E. uncinata* (Rud.) and *E. jugadornata* Soloviev which, as Cram points out, is almost identical with *E. uncinata*. The difference of size of body and the larger hooks in our specimen, combined with the difference in locality, suggest that we are dealing with a new species.

## SYNHIMANTUS sp.

Fig. 2

From *Microcarbo melanoleucus*. One female obtained, 7.2 mm. long. Lips broken (reconstructed in fig.). Cords narrow, extending 12 mm. from head, recurrent, anastomosing .7 mm. from head. Cervical papillae very large, tricuspid, .27 mm. from head. Vestibule .2 mm. long, about 10  $\mu$  wide. Tail tapering, .14 mm. long. Vulva 3 mm. from posterior end. Eggs 36  $\mu$  by 21  $\mu$ .

The proportions of the cordon and vestibule lengths, and the position and size of the cervical papillae do not agree with those of any species of *Synhimantus* of which we have a description.

## STREPTOCARA RECTA (Linstow)

A male of this species was taken from a marsh tern, *Chlidonias leucopareia*, and a female from *Microcarbo melanoleucus*. They agree with the description given by Yamaguti 1935.

## STREPTOCARA sp.

Fig. 3

A single female belonging to *Streptocara* was taken from *Querquedula gibberifrons*. Because of the paucity of the material and of the fact that only a distorted face view of the anterior end was obtainable, we have not attempted to classify it. The number of serrations in the collar and the irregular shape of the cervical papillae distinguish it from *S. recta*. It agrees in these characters with *S. crassicauda* (Creplin).

Length 7 mm.; cervical papillae about  $50\ \mu$  from anterior end, each with five to six irregular teeth. Vestibule about  $15\ \mu$  long,  $11\ \mu$  wide; anterior oesophagus  $\cdot 36$  mm.; posterior  $1\cdot 1$  mm.; nerve ring  $\cdot 1$  mm. from head. Anus almost terminal, posterior end of body rounded; vulva not observed; eggs  $19\ \mu$  by  $32\ \mu$ .

**Tetrameres pelecani n. sp.**

Fig. 4-5

From *Pelecanus conspicillatus*. One male found, a fine coiled worm 6 mm. long. Anterior end truncated, with six small lips, two of them (either laterals or dorsal and ventral) narrower than the others. No papillae seen. Buccal capsule strongly chitinized,  $7\ \mu$  wide internally, walls about  $1\cdot 5\ \mu$  thick,  $15\ \mu$  long, resting on chitinized ring at anterior end of oesophagus. Oesophagus  $1\cdot 5$  mm. long, not divided into anterior and posterior parts. Tail  $\cdot 18$  mm. long, tapering to blunt

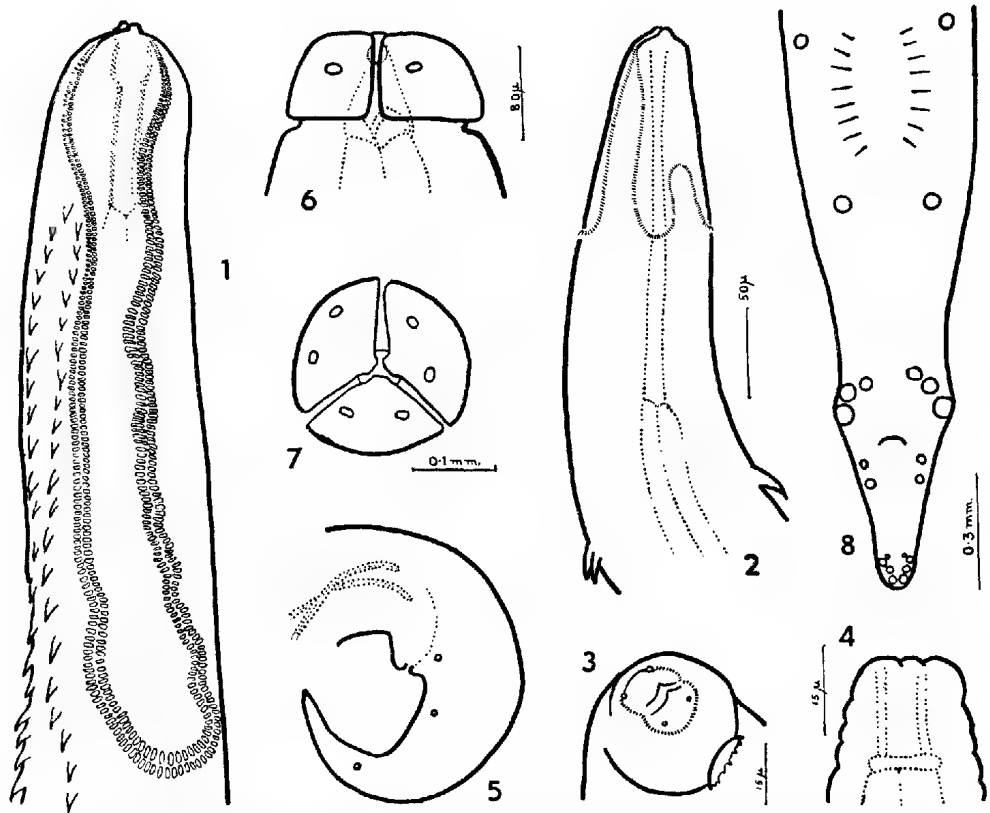


Fig. 1, *Echinuria querquedulae*, anterior end. Fig. 2, *Synhimantus* sp., anterior end. Fig. 3, *Streptocara* sp., head. Fig. 4-5, *Tetrameres pelecani*: 4, head; 5, male tail. Fig. 6-8, *Leipoanema ellisi*: 6, head; 7, head, face view; 8, male tail. Fig. 1 and 2 to same scale; fig. 5 and 6.

tip. No preanal papillae; three pairs small postanal, distributed as in fig. 5. Cloaca with prominent lips. Spicules needle-shaped but blunt-tipped, 1.5 mm. and .13 mm. in length respectively.

The assignment of the specimen to *Tetrameres* is made with some doubt. The characters of the anterior end suggest *Tetrameres*, but the absence of spines on the body is an unusual, though not a unique, feature of the genus. In its small size and the number of caudal papillae in the male, it differs from *T. paradoxa* (in which the presence of body spines is uncertain) and from *T. gynaccophila* (Molin) in which the male is without spines.

#### EPOMIDIOSTOMUM UNCINATUM (Lundahl)

One male 4 mm. long, one female 8.2 mm. long, and several pieces were taken from *Querquedula gibberifrons*. The worms are smaller than any previously recorded for the species, but the various parts bear the same relations to one another.

#### *Leipoanema ellisi* n. g., n. sp.

Fig. 6-8

From a mallee hen, *Leipoa ocellata*. Males about 12-15 mm. long; females 25-30 mm. Head with three lips, joined to each other internally near their anterior margins to surround narrow mouth opening, their posterior borders sharply outlined by a cuticular groove separating the "head" from the rest of the body. Each lip with two papillae and ending in small projecting part, seen only in face view. Buccal capsule wider at base than at mouth opening, .1 mm. long, with three rounded teeth at its base. Oesophagus 1.5 mm. long in male, 1.9-1.7 mm. in female, including bulb .24 mm. long in male, and .3 mm. in female. Excretory pore .8 mm. from anterior end in female; nerve ring .28 mm. in male.

*Male*—Caudal alae very narrow. Middle of elongate sucker 1.2 mm., and cloaca .35 mm. from rounded posterior end. Caudal papillae in three groups, a pair at each end of sucker, five pairs around cloaca (three of which are preanal and two postanal), and four pairs near tip of tail. Spicules equal, 2.16 mm. long; gubernaculum trough-shaped, .15 mm. long.

*Female*—Tail long, tapering, 1.4 mm. Vulva just anterior to mid-body; eggs thick-shelled, sub-globular, about 63  $\mu$  in diameter.

The characters of the oesophagus and male tail suggest relationship with the Subulurinae, and especially with *Subulura* and *Aulonocephalus*; the presence of three such deeply demarcated lips, however, distinguishes it from these and all other genera of the Subulurinae. A new genus is therefore proposed, with the following characters:

Subulurinae—Three lips separated from each other and from the rest of the body by deep cuticular grooves, two papillae on each lip; buccal cavity with three teeth at its base; oesophageal bulb present. Male—Preanal sucker and gubernaculum present, caudal alae very narrow; spicules equal; caudal papillae present. Female—Vulva in front of mid-body; eggs thick-shelled, sub-globular. Type, *Leipoanema ellisi* n. sp.

#### PHOCASCARIS spp.

Several very minute worms from *Pelecanus conspicillatus* are referable to the genus *Phocascaris*, since they possess an intestinal and an oesophageal appendix and lack interlabia. Owing to the size of the worms the presence or absence of teeth on the lips cannot be determined. The oesophagus is .6 mm. long, the intestinal caecum .36 mm., the oesophageal appendix .3 mm., and the tail 72  $\mu$ . No reproductive organs are distinguishable. In spite of the size of the worm, the lips are apparently completely developed.

# **A NEW APTEROUS DIPTERON (SCATOPSIDAE) FROM SOUTH AUSTRALIA**

By H. WOMERSLEY, A.L.S., F.R.E.S., South Australian Museum

## **Summary**

Scatopse aptera n. sp.

Description-Male: Colour entirely dark black. Length to 1.2mm. Wings absent. Halteres represented by mere vestiges. Eyes holoptic with comparatively few facets, bare. Antennae with 10 segments, segments I, II and X longer than wide, all segments with fine pubescence and whorls of fairly long hairs. Palpi 1-segmented, about two and a half times as long as wide. Legs moderately long, strong and fairly stout, anterior femora rather broader than rest; tibiae without apical spines; claws two, simple, with pad-like empodium; legs with fine pubescence and short strong spine-like setae, tarsi 4-segmented. Scutellum present, but small and apparently somewhat hidden under the first abdominal segment. Abdomen ventorally and ventro-laterally longitudinally striated, as in other species of *Scatopse* and also *Thripomorpha*. The clothing of the thorax and abdomen consists of fine pubescence and short, strong spine-like setae.



**A NEW APTEROUS DIPTERON (SCATOPSIDAE)  
FROM SOUTH AUSTRALIA**

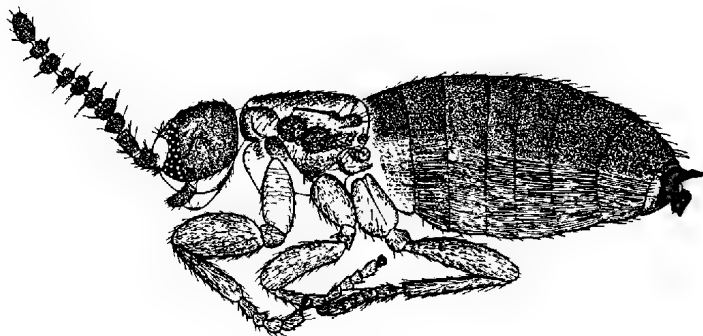
By H. WOMERSLEY, A.L.S., F.R.E.S., South Australian Museum

[Read 11 June 1942]

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Fig.

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*Remarks*—In general appearance this insect resembles the curious thrips-like *Thripomorpha paludicola* described by Enderlein in 1904 from Germany. Enderlein's genus and species, however, has a 12-segmented antenna, a more pronounced scutellum and specialised structure of the tarsi.

*Locality* — Two specimens found in the debris of a decayed Yacca (*Xanthorrhoea*) stump, Adelaide, 10 April 1939, with the aid of the Berlese funnel by R. V. Southcott.

# **SOME AUSTRALIAN FRESHWATER GASTEROPODA**

By BERNARD C. COTTON, South Australian Museum

## **Summary**

Because of their economic importance as hosts of various trematodes parasitic in man and animals, it is extremely necessary that the systematics of the Freshwater Mollusca should be thoroughly understood.

## SOME AUSTRALIAN FRESHWATER GASTEROPODA

By BERNARD C. COTTON, South Australian Museum

[Read 11 June 1942]

Because of their economic importance as hosts of various trematodes parasitic in man and animals, it is extremely necessary that the systematics of the Freshwater Mollusca should be thoroughly understood.

In New South Wales intensive research has been undertaken on the sheep liver-fluke, and out of about twenty species of freshwater snails recorded from that district one, *Limnaea brazieri* Smith, was found to be the host carrier of the fluke. Similar investigations on this and other trematode worms have been carried out in South Australia by Professor T. Harvey Johnston, with consequent interesting and important discoveries. With the possible introduction of many tropical diseases with which trematode worms are associated such as *Heterophyes heterophyes*, *Metagonimus yokogawi*, *Paragonimus ringeri*, *Schistosoma mansoni*, *japonica* and *bovis* into Australia by the influx of internees, refugees, prisoners of war, etc., it is of immediate importance that our freshwater fauna be thoroughly investigated so that a strict watch may be kept to avoid the possibility of these trematodes selecting a local host.

In preparing this preliminary paper, South Australian and West Australian species were particularly studied and records for Kangaroo Island listed. Roughly the South Australian Area may be subdivided into regions each having its own assemblage of freshwater life, though these regions are not very well marked. The regions are:

- (a) The Lower Murray.
- (b) The creeks and rivers of the Adelaide Hills.
- (c) Eyre Peninsula and Kangaroo Island.
- (d) The Flinders Range and Far North of South Australia.
- (e) The South-East with its odd Victorian species.

In the few previous lists which have been published numerous duplications of names have been made and preoccupied names used, while some old and valid names have been entirely overlooked. Localities have also been confused.

## Genus AMERIANNA Strand 1928

*Ameria* Adams, 1861, P.Z. Soc., Lond., 143, preoc.; nec *Ameria* Walker 1854, Lep. Insects, Brit. Mus., 2, 554.

*Amerianna* Strand 1928, Arch. Naturgesch., 92, A. 8; 1926, 63.

Adams' generic description reads: "Shell with the whorls flattened, and angulated or carinated at the posterior part; spire short, depressed." The first species following this description is *Physa* (*Ameria*) *carinata* Adams, and the description of this is: "Shell subovate, thin, pale yellowish-brown; spire very short, the apex flat; whorls three, flattened and strongly carinated posteriorly; aperture subovate, columellar plait moderate. Long, 5½ in.; diam., 3¼ in. Habitat Boyne River, Australia."

The animal of *Amerianna* has not the produced and reflected mantle lobes of *Physa* and the radula resembles that of *Planorbis* rather than *Limnaea*, and shows some affinity to that of the African genus *Isidora*.

Under this genus Adams lists the following species:

- A. truncata* Adams 1861, from the Calliope River, South Queensland.
- A. obesa* Adams 1861, from the Fitzroy River, North Queensland.
- A. cumingii* Adams 1861, from Port Essington, Northern Australia.
- A. moesta* Adams 1861, from New Zealand.

The species most closely related to this group in South Australia is *A. aliciae* Reeve 1862, from the Lower River Murray.

Some fifty species of "*Physa*" have been described from Australia. As they have nothing whatever to do with *Physa* it is proposed to place them all under the genus *Amerianna*. No doubt this will be split up by future workers, but until more animals have been examined splitting seems inadvisable. The typically carinate shell appears so different from the ordinary *tenuistriata* type with its taller spire and rounded whorls that a division seems necessary. Considering the variability in carination and length of spire, however, the species had better all remain in *Amerianna* until further information is forth-coming.

#### AMERIANNA ALICIAE (Reeve 1862)

*Physa aliciae* Reeve 1862, P.Z. Lond., 106, text fig.; *cingulata* Clessin 1886, Syst. Conch. Cab., 17, 364, pl. li, fig. 8 (locality, South Australia). Type locality, Lower Murray.

*Distribution*—General in South Australia; Rivers Para, Torrens and Onkaparinga; creeks in the Mount Lofty Ranges; Lake Alexandrina and Lake Bonney near Barmcr, and in water towers and pipes around Adelaide.

There is considerable variation in the strength of the keeling and length of spire in different specimens.

#### AMERIANNA SUBUNDATA (Sowerby 1873)

*Physa subundata* Sowerby 1873, Conch. Icon., 19, pl. viii, fig. 61; *pinguis* Sowerby 1873, Conch. Icon., 19, pl. xii, fig. 93, loc. South Australia; *bullata* Sowerby 1873, Conch. Icon., 19, pl. xii, fig. 97, loc. South Australia.

*Type Locality* for *subundata* is "St. Margaret's, South Australia."

*Distribution*—River Torrens; Rocky River, Kangaroo Island.

Sowerby 1873 gives the following description: "Shell olive-brown, ventricose, concentrically slightly undulated; spire rather short, apex acuminate, penultimate whorl broad, rather angular, last whorl large, swelled near the suture, roundly angular; aperture large, striped with chestnut within near the border; columella fold rather thick, tortuous."

According to Cockburn, "Nomenclature of South Australia," revised edition (manuscript), Saint Margaret's, is a subdivision of the Port Adelaide district.

Although this species may yet prove to be an extreme variant of the *tenuistriata* complex, it can be picked out readily from River Torrens specimens by the solidity of the shell, faint almost obsolete spiral striae and the odd yellow and brown axial colour bands.

*Physa bullata* Sowerby 1873, type locality South Australia, is a juvenile specimen, quite typical of the species in general shape.

#### AMERIANNA TENUISTRIATA (Sowerby 1873)

*Physa tenuistriata* Sowerby 1873, Conch. Icon., 19, pl. x, fig. 85; *texturatus* Sowerby 1873, Conch. Icon. 19, pl., xii, fig. 95, South Australia; *smithi* Clessin, 1886, Syst. Conch. Cab., 17, 294, pl. xlii, fig. 2, 3, River Murray; *conica* Clessin, 1886, Syst. Conch. Cab., 17, 360, pl. li, fig. 3, South Australia; *waterhousei* Clessin, 1886, Syst. Conch. Cab., 17, 361, pl. li, fig. 6, South Australia.

*Ameria tenuistriata* Gabriel, 1939, Mem. Nat. Mus. Melb., No. 11, 111, pl. i, fig. xii, Victoria.

*Type Locality* for *Physa tenuistriata* is the River Torrens, South Australia.

*Distribution*—General and common in South Australian rivers, creeks, swamps and reservoirs.

This species, like many other of the genus, is very variable, and consequently many names have been given to it. Some of these synonyms have not previously been listed by Australian authors. Gabriel, 1939, recorded five Victorian varieties under a trinomial nomenclature, but this seems inadvisable as the "subspecies" thus named are probably only local variants.

*Physa texturata* Sowerby 1873, has strong axial and slightly less strong spiral striae and the shell is thick, sculpture coarse.

*Physa smithi* Clessin, 1886, is a thin-shelled faintly striate variant.

*Physa conica* Clessin, 1886, is a very narrow species according to the figure and is unlike any Australian shell known. It is possible that there has been some error in type locality. It is, however, described as "*minute striata*" and may be an inaccurately figured form of *P. tenuistriata*.

*Physa waterhousei* Clessin, 1886, is a direct synonym of *P. tenuistriata* Sowerby, the figure by Clessin being typical.

#### AMERIANNA SUBACUTA Cotton and Beasley 1941

*Amerianna subacuta* Cotton and Beasley, 1941, S. Aust. Nat., 21, No. 1, 17.

Holotype from River Torrens at Marden, South Australia, Reg. No. D. 19081, South Australian Museum.

*Distribution*—Creeks running from the Mount Lofty Ranges; Adelaide Plains.

This species was in the South Australian Museum collection under the name *Physa pyramidatus* Sowerby. Sowerby's species was described from "Australia," but has since been recognised as the common Victorian and North Tasmanian species, which is considerably larger and more elongate than any South Australian species.

#### AMERIANNA LINCOLNENSIS (Clessin 1886)

*Physa lincolnensis* Clessin 1886, Syst. Conch. Cab., 17, 363.

*Type Locality*—Port Lincoln, South Australia.

*Distribution*—Eyre Peninsula and Kangaroo Island.

This long-spined, smooth species appears different from other species recorded from South Australia. It does not show the decussate sculpture of *tenuistriata* and its allies and is a much more solid shell than its nearest relative *subacuta*. Until further material is available to prove or disprove the validity of the species it is here listed as distinct.

#### *Amerianna gabrieli* nom. nov.

*Physa (Ameria) truncata* Adams 1861, P.Z. Soc., 143; nec *Physa truncata* Bourguignat 1856, Amern. Malac., 1, 170, pl. xxi, fig. 5-7.

*Type Locality*—Calliope River, South Queensland.

*Distribution*—Rivers of South Queensland.

The name *truncata* introduced by Adams for this South Queensland species with the truncate spire is pre-occupied by *truncata* Bourguignat, an entirely different North African species. The above name, after the noted Victorian conchologist, C. J. Gabriel, is therefore introduced.

The Australian species of *Amerianna*, with type localities, listed according to the various river systems are as follows:

(1) The Darling, Murrumbidgee, Murray and their tributaries and the river captures of South-East Queensland.

*Amerianna novaehollandiae* Blainville 1925, Macquarie River, New South Wales, originally described from "New Holland"; *lessoni* Smith 1882, Australia

= *novae-hollandiae* Lesson 1830, New Holland; *aliciae* Reeve 1862, Lower Murray, South Australia = *cingulata* Clessin 1886, Lower Murray, South Australia; *pectorosa* Conrad 1866, Bogan River, New South Wales; *subundata* Sowerby 1873, Adelaide Plains, South Australia = *pinguis* Sowerby 1873, South Australia = *bullata* Sowerby 1873, South Australia; *australiana* Conrad 1850, Bogan River, New South Wales; *tenuistriata* Sowerby 1873, River Torrens, South Australia = *texturatus* Sowerby 1873, South Australia = *smithi* Clessin 1886, South Australia = *conica* Clessin 1886, South Australia = *waterhousei* Clessin 1886, South Australia = *puncturata* Sowerby 1874, South Australia; *subacuta* Cotton and Beasley 1941, River Torrens, South Australia; *confluens* Hedley 1917 Echuca, Victoria.

(2) Rivers of Eastern New South Wales, also Victoria and Northern Tasmania.

*Amerianna gibbosa* Gould 1847, "New South Wales," Cooks River, near Sydney, coastal New South Wales = *adamsiana* Canefri 1873, Australia = *grayi* Smith 1883, New Holland = *novae-hollandiae* Gray 1834, New Holland = *novae-hollandiae* Sowerby 1873, New Holland; *marginata* Kuster 1844, "New Holland" probably coastal New South Wales = *novae-hollandiae* Anton 1938, New Holland = *ludwigii* Kuster 1844, New Holland; *acutispira* Tryon 1886 "Australia probably Victoria; *yarraensis* Tenison Woods, Upper Yarra, Victoria; *etheridgii* Smith 1882 Yan Yean Reservoir, Victoria, may be a synonym of *acutispira*; *pyramidata* Sowerby 1873, "Australia" probably Flinders Island, Bass Strait, also found in Victoria and Northern Tasmania; *aciculata* Sowerby 1873, "New South Wales" probably Coastal New South Wales; *fusiformis* Nelson and Taylor 1879, Richmond River, New South Wales; *kershawii* Tenison Woods 1878, Upper Yarra, Victoria; *aperta* Sowerby 1873, Hamilton, Northern Tasmania; *tasmanica* Tenison Woods 1875, Great Lake, Central Tasmania; *tasmanicola* Tenison Woods 1875, Mount Mary, central east coast Tasmania; *eburnea* Sowerby 1874, near Launceston, North Tasmania = *attenuata* Sowerby 1874, Lake Dulverton, North Tasmania, closely allied to *pyramidata*; *ciliata* Tenison Woods 1875, Lake Dulverton, North Tasmania; *vandiemensis* Sowerby 1873, Northern Tasmania; *kreftii* Clessin 1886, Calverts Creek, New South Wales.

(3) Coastal Rivers of South Queensland and North New South Wales from Bundaberg to Grafton.

*Amerianna producta* Smith 1882, Clarence River, Grafton, New South Wales; *carinata* Adams 1861, Boyne River, Queensland; *gabrielii* Cotton 1942, Calliope River, Southern Queensland = *truncata* Adams 1861, preoc.; *brisbanicus* Nelson and Taylor 1879, Brisbane, River Brisbane, Queensland; *duplicata* Sowerby 1873, Wide Bay, Queensland; *tortuosa* Clessin 1886, "Urara River, undoubtedly Orara River, tributary of the Clarence River, Northern New South Wales; *multispirata* Clessin 1886, "Urara River," i.e., Orara River, Northern New South Wales.

(4) Coastal Rivers of Queensland, from Bundaberg northwards.

*Amerianna obesa* Adams 1861, Fitzroy River, Queensland; *beddomei* Nelson and Taylor 1879, Townsville, Queensland; *gracilentia* Smith 1882, Endeavour Queensland, *queenslandica* Smith 1882, Dawson River, Queensland.

(5) Coastal Rivers of the Northern Territory from Port Essington to the Queensland Border.

*Amerianna cumingi* Adams 1861, Port Essington, north Western Australia; *reevei* Adams and Angas 1863, Arnheim Land, Northern Australia; *bonushenricus* Adams and Angas 1863, Arnheim Land, Northern Australia; *badia* Adams and Angas 1863, a tributary of the Adelaide River, Arnheim Land, Northern Australia; *olivacea* Adams and Angas 1863, Arnheim Land, Northern Australia; *connexinna* Adams and Angas, Arnheim Land, Northern Australia.

- (6) The Coastal Rivers of Middle Western Australia from Port Essington southwards to Geraldton.

*Amerianna exarata* Smith 1882, Depuch Island, North Western Australia; *cumingi* Adams 1861, Port Essington, North Western Australia.

Specimens seem to indicate that these may probably extend southwards. Otherwise this region has not been investigated as far as the freshwater shells are concerned.

- (7) The Coastal Rivers of South Western Australia, from Geraldton in the north to the western end of the Great Australian Bight.

*Amerianna georgiana* Quoy et Gaimard 1832, King George Sound, Western Australia; *australis* Kuster 1844, Western Australia = *elongata* Menke 1843 (preoc. Say 1821), South Western Australia; *breviculmen* Smith 1882, King George Sound, Western Australia; *quoyi* Smith 1882, King George Sound, Western Australia; *tenuilirata* Smith 1882, Swan River, Western Australia; *decorata* Thiele 1930, Brancaster, Upper Blackwood District, near Cape Leeuwin, South Western Australia.

- (8) The Rivers and Lakes of Central Australia westward of the Darling, and embracing the Coastal Area of the Great Australian Bight.

*Amerianna lincolnensis* Clessin 1886, Port Lincoln, Eyre Peninsula, South Australia.

The genus *Isidorella* which is widely spread in this area seems to take the place of *Amerianna* so common elsewhere, though species of *Amerianna* occur there and will be described in a later paper.

- (9) The Rivers of Southern Tasmania.

*Amerianna nitida* Sowerby 1873, South-east Tasmania; *mamillata* Sowerby 1873, Bruni Island, South Tasmania; *huonensis* Tenison Woods 1875, Huon River, South Tasmania = *legrandi* Tenison Woods, Richmond, South Tasmania = *huonicola* Tenison Woods 1875, Upper Huon River, South Tasmania; *tasmanicola* Tenison Woods 1875, Mount Murray, east coast Tasmania; *bruniensis* Sowerby 1874, Bruni Island, South Tasmania.

#### Genus ISIDORELLA Tate 1896

*Isidorella* Tate 1896, Horn Exped., 1, 212.

Genotype *Physa newcombi* Adams and Angas.

The characters of this genus may be summarised as follows: Shell oval, last whorl much inflated, peritreme continuous, adnate to the parietal wall and forming a false umbilicus; columella without a fold; periostracum horny, raised into spiral fringes of hairs and into imbricating folds at the suture; spiral rows of hairs superimposed on the spiral striae of the test. Animal with tentacles slender, suddenly dilated at the base of the upper outer side, the eyes on the inner base of the tentacles, the mantle not exsert, with a plain margin; dentition related to *Planorbis*.

The following Australian species belong to this genus: *newcombi* Adams and Angas, 1863, from a pond near Mount Margaret, Central Australia = *physopsis* Cooks, 1887, "Australia" = *contortula* Clessin, 1886, "Australia"; *subinflata* Sowerby, 1873, South Australia; *rubida* Cotton and Godfrey, Yabmana, Franklin Harbour, Eyre Peninsula, South Australia; *brazieri* Smith 1882, Ashfield, near Sydney, New South Wales; *pallida* Smith 1882, Rooty Hill, near Chatsworth, New South Wales; *major* Smith 1882, Burnett River, Queensland; *ferruginea* Adams and Angas, 1863, from a tributary of the Adelaide River, Arnhem Land, North Australia; *hainesii* Tyron, 1886, Australia—probably Victoria; *pilosa* Tenison Woods, 1878, Melbourne, Victoria = *crebreciliata* Tenison Woods, Caulfield, Victoria = *hirsuta* Tenison Woods MSS., Tasmania; *egregia* Preston, North Western Australia.

## ISIDORELLA NEWCOMBI (Adams and Angas 1863)

*Physa newcombi* Adams and Angas 1863, P.Z. Soc., 1863, 416.

*Type Locality*—Pond near Mount Margaret, Central Australia.

*Distribution*—Central Australia Fifteen Mile Creek, River Finke country, Storm Creek, Alice Springs.

## ISIDORELLA SUBINFLATA (Sowerby 1874)

*Physa inflata* Adams and Angas, 1864, P.Z. Soc., 39, (pre-occupied); nec *inflata* Lea, 1941, P. Am. Phil. Soc., 11, No. 17, 32; nec *fontinalis inflata* Moquin-Tandon, 1855, Hist. Nat. Moll., 11, 451, pl. xxxii, fig. 13; *subinflata* Sowerby 1874, Conch. Icon., pl. i, fig. 4.

*Isidora newcombi hedleyi* Clench, 1926, J. Conch., 18, No. 1, 12.

*Type Locality*—South Australia (*subinflata*), Wakefield River, South Australia (*inflata*).

*Distribution*—River Torrens, Wakefield River, River Para, River Angas, Mount Pleasant, Penola, Tatiara Creek, Wirrabara; also Rocky River, Kangaroo Island.

## ISIDORELLA RUBIDA Cotton and Godfrey 1932

*Isidorella rubida* Cotton and Godfrey 1932, S. Aust. Nat., 13, 160, pl. ii, fig. 7.

*Type Locality*—Yabmana, Franklin Harbour, Eyre Peninsula, South Australia.

*Distribution*—Eyre Peninsula; Kangaroo Island.

Shell ovate-globose, solid, dark reddish-brown in life; aperture violet within, margin of columella and outer lip white; colour frequently faded in dead shells. Animal carmine coloured. Height 13 mm., diameter 10.5 mm. The species is best described as intermediate in shape between *subinflata* and *newcombi*. The colour of the animal and shell is distinctive and quite different from either species.

Genus **Austropeplea** gen. nov.

Genotype *Limnaca papyracea* Tate 1889, Trans. Roy. Soc. S. Aust., 3, 103, pl. iv, fig. 5 = *Limnaca aruntalis* Cotton and Godfrey, 1938, Gastr. S. Aust., 36.

Shell ovate, thin, shining, axially wrinkled, spire short, whorls rounded at the sutures, last whorl ovate-oblong, anteriorly expanded; outer lip sinuously produced about the middle; columella fold slender, slightly tortuous; inner lip widely and thinly spread. Animal with mantle lobes entirely covering the shell and foot and so voluminous that it cannot be wholly withdrawn into the wide-mouthed shell.

This species has been placed in *Limnaca*, genotype *stagnalis* with which there is no similarity; in *Myxas*, genotype *glutinosa* to which the shell bears little resemblance; also in *Amphipeplea* which is a synonym of *Myxas* with the same genotype; all these are European genera.

## AUSTROPEPLEA ARUNTALIS (Cotton and Godfrey 1938)

*Limnaca aruntalis* Cotton and Godfrey 1938, Gastr. S. Aust., 36; *Limnaca papyracea* Tate, 1880, Trans. Roy. Soc. S. Aust., 3, 103, pl. iv, fig. 5, preoc.; nec *Limnaca papyracea* Spix, 1827, Test. Bras., 17, pl. x, fig. 5.

*Type Locality*—Bed of dried up marsh near Penola, South Australia.

*Distribution*—River Torrens; Kangaroo Island at Discovery Flat.



The species described by Spix from Brazil is quite distinct from the South Australian species. Related species are:

*Austropeplea huonensis* Tenison Woods, 1875, from the Huon River, South Tasmania. *A. launcestonensis* Tenison Woods, 1875, from a creek near Launceston, North Tasmania.

***Bythinella pattisoni* sp. nov.**

Fig. 1

Holotype, River Torrens, at Paradise Park, March 1942, Reg. No. D. 14095, South Australian Museum. Height, 5 mm., width 3 mm.

*Distribution*—Common in rivers, creeks, water towers, pipes and reservoirs in South Australia. River Murray at Tailem Bend, Lake Alexandrina, upper reaches of the Port River, Franklin Harbour, Eyre Peninsula, Kangaroo Island at Raining Creek, Stunsail Boom River and Upper Cygnet River, Onkaparinga at Port Noarlunga, Hallett's Cove, Glenelg and Meadows.

Shell small, ovately conical, dark horn colour, frequently carrying an earthy deposit; whorls six, rounded, slightly bulbous, smooth, separating suture deep; aperture pinkish white, outer and inner lip slightly thickened and well defined; base imperforate; operculum horny but slightly calcareous, paucispiral, ear-shaped, nucleus towards the base and columella margin. The species is found in hundreds on the underside of small smooth stones in pools left in the partly dried up bed of the River Torrens. Numerous small transparent capsules about one-quarter by one-sixteenth of an inch, in the same position as the shells, are probably the egg capsules of the species. The Waterworks Department has frequently forwarded this shell in quantities to the Museum, taken from various pipes and meters.

Some of the records are as follows: Prospect, at Halstead Street, blocking water meter. Kintore Avenue, City, Teachers' Training College, from water pipe. Marryatville, blocking water meter. Burnside, Portrush Road, blocking water meter. Toorak, Grant Avenue, residence of W. A. Holden, blocking water meter, situated at fifteen feet from a 3-inch water main. In the last were also juvenile specimens of *Amerianna aliciae* Reeve.

BYTHINELLA BUCCINOIDES (Quoy et Gaimard 1835)

*Paludina buccinoides* Quoy et Gaimard 1835, Zool. Astrolabe, 3, 175, pl. lviii, fig. 13, 14.

*Bythinia victoriac* Tenison Woods, 1878, P. Roy. Soc. Vict., 14, 65.

*Type Locality*—Western Port, Victoria (*buccinoides*), Geelong (*victoriae*).

*Distribution*—Victoria, Northern Tasmania, and the South-East of South Australia. We have specimens in the South Australian Museum collection from Eight Mile Creek, South-East South Australia (Cleland).

TATEA RUFILABRIS (Adams 1862)

*Diala rufilabris* Adams 1862, Ann. Mag. Nat. Hist., (3), 10, 298.

*Tatea rufilabris* Smith, 1881, Linn. Soc. (Zool.), 16, 268, pl. vii, fig. 19; Thiele, 1929, Hand. der Syst. Weicht., 1, 168, fig. 146; Pilsbry, 1897, Acad. Nat. Sce., Philad., 360, pl. ix, fig. 9.

*Type Locality*—Port Lincoln, South Australia.

*Distribution*—Kangaroo Island, from Cygnet and Harriet Rivers; Patawalunga, River Torrens.

Smith, 1882, writes: "The operculum is said to be calcareous, with a sub-marginal claw. As far as I can discover, judging from an external view, it appears to be thin, horny, paucispiral, with the nucleus subcentral, but rather towards the base or lower end."

The operculum is paucispiral, ear-shaped, nucleus towards the base and columella side; the claw is calcareous, situated at the back of the operculum, and 6-digitate with a longitudinal narrow calcareous base.

Pilsbry, 1897, figures the operculum of *Tatea paradisiaca* Pilsbry, but his crude drawing gives no idea of the claw which is also digitate. His key to the three Australian species of *Tatea*, however, is correct, and the species are certainly separable, as he suggests. They are: *rufilabris* Adams 1862, Port Lincoln, South Australia; *huonensis* Tenison Woods, 1879, genotype, Huon River, South Tasmania; *paradisiaca* Pilsbry, 1897, Eden, New South Wales. To these can be added *preissii* Philippi 1846, Western Australia = *acuta* Menke 1843, preoc., Swan River, Western Australia.

The radula definitely locates this genus in the Family Hydrobiidae.

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 SMITH, E. A. 1882 J. Linn. Soc. (Zool.), Lond., 16, 255-317, pls. v-vii  
 SOWERBY, G. B. 1873-1874 Conch. Icon., 19, pls. i-xii  
 TATE, R. 1882 Proc. Linn. Soc. N.S.W., 6, 552-569

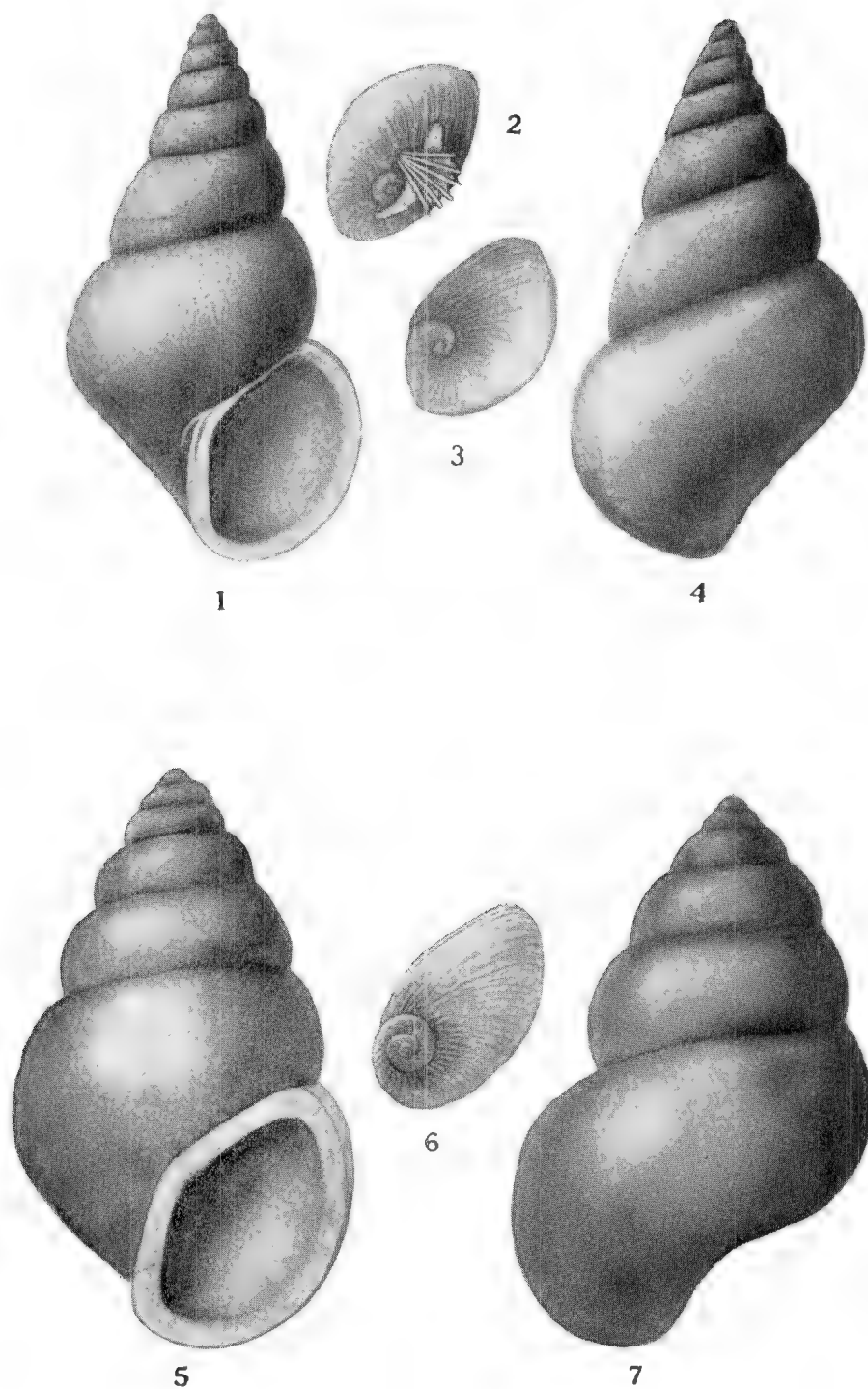
#### EXPLANATION OF PLATES I AND II

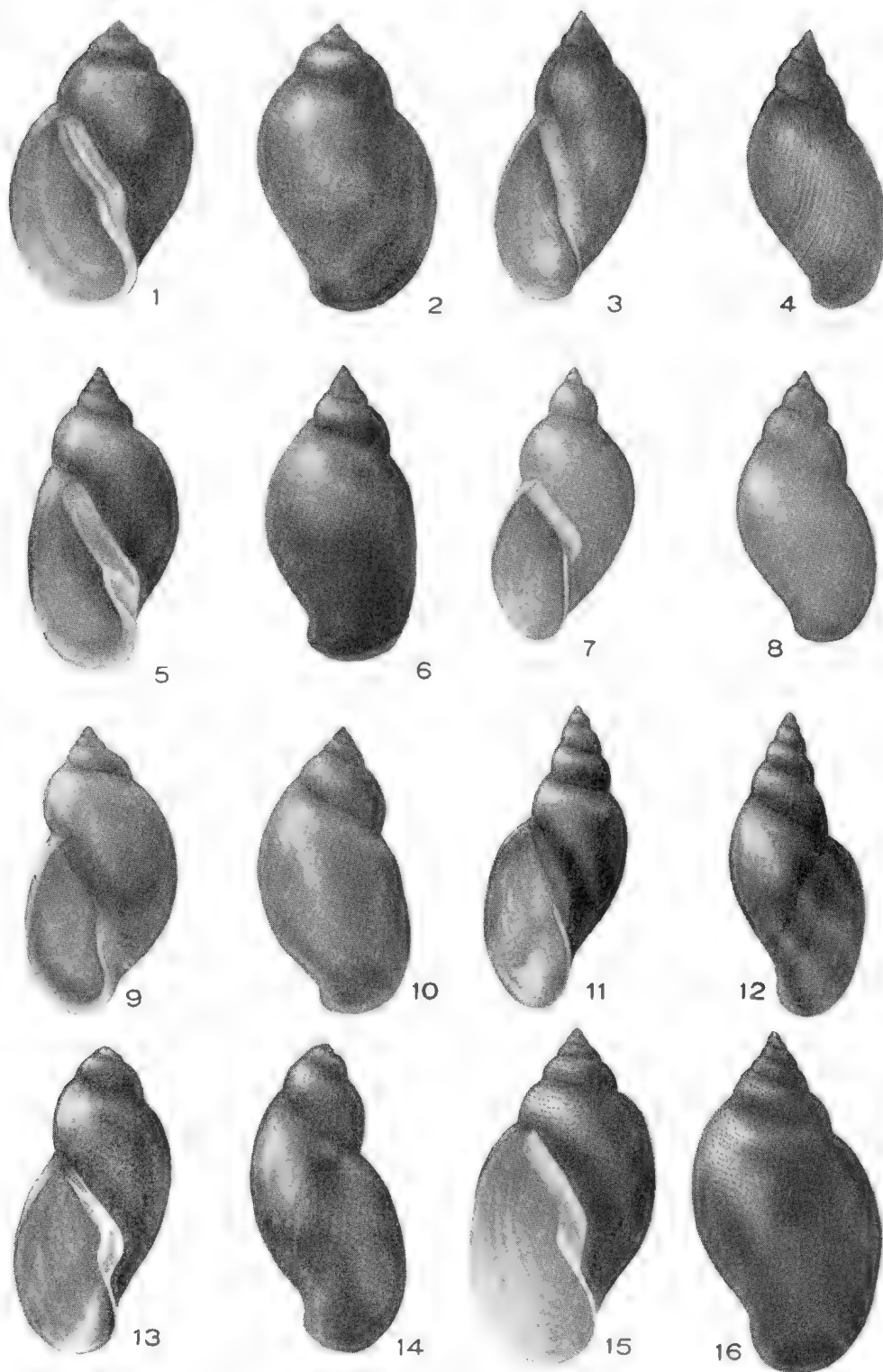
##### PLATE I

Fig. 1 *Tatea rufilabris* Adams, dorsal view, x 12. Fig. 2 *Tatea rufilabris* Adams, operculum, inside view, x 12. Fig. 3 *Tatea rufilabris* Adams, operculum, outside view, x 12. Fig. 4 *Tatea rufilabris* Adams, ventral view, x 12. Fig. 5 *Bythinella pattisoni* sp. nov., ventral view, x 15. Fig. 6 *Bythinella pattisoni* sp. nov., operculum, outside view. Fig. 7 *Bythinella pattisoni* sp. nov., dorsal view.

##### PLATE II

Fig. 1 and 2 *Amerianna subundata* Sowerby, River Torrens, S. Aust., x 3. Fig. 3 and 4 *Amerianna subacuta* Cotton, River Torrens, S. Aust., x 3. Fig. 5 and 6 *Amerianna tenuistriata* Sowerby, River Torrens, S. Aust., x 3. Fig. 7 and 8 *Amerianna lincolniensis* Clessin, Port Lincoln, S. Aust., x 3. Fig. 9 and 10 *Amerianna breviculum* Smith King George Sound, W. Aust., x 3. Fig. 11 and 12 *Amerianna tasmanicola* Tenison Woods, Mount Murray, Tasmania, x 4. Fig. 13 and 14 *Amerianna pyramidata* Sowerby, Victoria, x 2. Fig. 15 and 16 *Amerianna ciliata* Tenison Woods, Lake Dulverton, Tasmania, x 3.





# **CEPHALOPODA FROM STOMACH CONTENTS OF FISH FROM EAST AND SOUTH AUSTRALIA**

By BERNARD C. COTTON, South Australian Museum

## **Summary**

In 1940 Dr. H. Thompson, Chief of Division of Fisheries, Marine Biological Laboratory, Cronulla, kindly forwarded many interesting specimens of Cephalopoda (cuttle fishes, etc.), taken off the Australian coast. Included were fragments taken from the stomachs of Tuna, Albacore and other fishes, and a preliminary report was prepared in manuscript. As very definite localities are given for all the specimens, and as some Cephalopoda form a principal article of diet of certain edible fishes, this short paper covers the early part of the report submitted.

# CEPHALOPODA FROM STOMACH CONTENTS OF FISH FROM EAST AND SOUTH AUSTRALIA

By BERNARD C. COTTON, South Australian Museum

[Read 11 June 1942]

In 1940 Dr. H. Thompson, Chief of Division of Fisheries, Marine Biological Laboratory, Cronulla, kindly forwarded many interesting specimens of Cephalopoda (cuttle fishes, etc.), taken off the Australian coast. Included were fragments taken from the stomachs of Tuna, Albacore and other fishes, and a preliminary report was prepared in manuscript. As very definite localities are given for all the specimens, and as some Cephalopoda form a principal article of diet of certain edible fishes, this short paper covers the early part of the report submitted.

## NOTOTODARUS GOULDI (McCoy 1888)

*Onumastrophes gouldi* McCoy 1888, Prod. Zool. Vict., (17), 2, 255, pl. clxix, 170, Victorian coast; *Nototodarus gouldi* (McCoy), Cotton and Godfrey, 1940, Moll., S. Aust., (2), 392, fig. 384-388.

*Distribution*—New South Wales, Victoria, Tasmania, South Australia, Western Australia.

The following exact records of localities are now listed:

- 16 November 1938—Fragments from stomach of Bluefin, *Thunnus maccoyii* from Jervis Bay, New South Wales.
- 25 November 1938—Partly digested fragments from stomach of Albacore, *Thunnus germon*, from twelve miles east of Babel Island, off Flinders Island.
- 9 October 1939—Partly digested juveniles from stomach of Bluefin *Thunnus maccoyii*, from Bass Strait between Gabo Island and Flinders Island.
- 9 October 1939—Partly digested fragments from stomach of Bluefin, *Thunnus maccoyii*, from between Green Cape and Cape Everard.
- 17 October 1939—Fragments from stomach of Bluefin, *Thunnus maccoyii*, from Pambula, New South Wales.
- 1 November 1939—Fragments of adults and juveniles from stomach of Bluefin, *Thunnus maccoyii*, from Tollgates Island, New South Wales.
- 4 November 1939—One adult and four juveniles, all females, taken in dip net at night near submarine light, Port Arthur, Tasmania.
- 18 February 1940—Four specimens partly digested from stomach contents of *Thunnus maccoyii*, taken at Cape Pillar, Tasmania.

## SEPIOTEUTHIS AUSTRALIS Quoy and Gaimard 1832

*Sepioteuthis australis* Quoy and Gaimard 1832, Voy. Astrolabe, 2, 77, pl. iv, fig. 1, Western Port, Victoria; Cotton and Godfrey, 1940, Moll., S. Aust., (2), 414, fig. 402-405.

*Distribution*—Western Australia, South Australia, Victoria and New South Wales.

- 19 February 1939—Twelve adult females, one juvenile, taken off Wallaroo Jetty, South Australia, submarine light.
- 9 September 1939—Five juvenile females taken at Port Hacking, New South Wales.

## EUPRYMNA STENODACTYLA (Grant 1833)

*Sepiola stenodactyla* Grant 1833, Trans. Zool. Soc., Lond., 1, 84, pl. xi, fig. 1, 2, Port Jackson, New South Wales; *Euprymna stenodactyla* (Grant), Hedley 1918, J. Roy. Soc. N.S.W., 51, 33.

*Distribution*—New South Wales, South Australia.

- 19 February 1939—Two females from Wallaroo Jetty, South Australia, submarine light. This is a new record for South Australia.  
 19 June 1939—One adult female from Fortescue Bay, Tasmania, submarine light.  
 20 September 1939—One adult female from Gunnamatta Bay. Blackish and chestnut chromatophores on the body surface were noted during life.  
 14 February 1940—Four juvenile females from Lady Barron, and Flinders Island, Bass Strait.  
 26 February 1940—Three juvenile females from Wollongong, New South Wales, submarine light.

SEPIOLOIDEA LINEOLATA (Quoy and Gaimard 1832)

- Sepioloidea lineolata* Quoy and Gaimard 1832, Zool. Voy. Astrolabe, 2, 82, pl. v, fig. 8, 13, Jervis Bay, N.S.W.; *Sepioloidea lineolata* (Quoy and Gaimard), Cotton and Godfrey, 1940, Moll., S. Aust., (2), 405, fig. 396.  
*Distribution*—Western Australia, South Australia and New South Wales.  
 1 September 1939—One adult female from Gunnamatta Bay, New South Wales. Known as the "Tiger Squid." Common on mud flats.

SEPIA (SOLITOSEPIA) MESTUS Gray 1849

- Sepia mestus* Gray 1849, Ceph. Antep. Brit. Mus., 108, Port Jackson, N.S.W.  
*Sepia (Solitosepia) mestus* Gray, Cotton and Godfrey, 1940, Moll., S. Aust., (2), p. 440.  
*Distribution*—New South Wales.  
 16 November 1938—One partly digested adult specimen from stomach of *Seriola grandis* from Ulladulla, New South Wales.

SEPIA (SOLITOSEPIA) PLANGON Gray 1849

- Sepia plangon* Gray 1849, Ceph. Antep. Brit. Mus., 104; Port Jackson, N.S.W. *Sepia (Solitosepia) plangon* Gray, Cotton and Godfrey, 1940, Moll., S. Aust., 2, 441.  
*Distribution*—New South Wales.  
 1 September 1939—Three female adults from Gunnamatta Bay, New South Wales. One was dissected to confirm the identification and the gladius was found to be typical.

EUOPLUTEUTHIS GALAXIAS Berry 1918

- Euopluteuthis galaxias* Berry 1918, Biol. Res. Endeavour, 4, (5), 211, pls. lix-lx, Gabo Island, Victoria, 200-250 fathoms.  
*Distribution*—Victoria.  
 25 December 1939—One juvenile female about half the length of the holotype. Lat. 38° 42', long. 149° 23', taken in net N. 70, 200 metres oblique.

OCTOPUS PALLIDUS Hoyle 1885

- Octopus boscii* var. *pallidus* Hoyle 1885, Zool. Challenger, 16, 81, pl. i, ii, Twofold Bay, New South Wales. *Octopus pallidus* Hoyle, Cotton and Godfrey, Moll., S. Aust., 2, 449.  
*Distribution*—New South Wales, South Australia, Victoria, Tasmania and Western Australia.  
 20 October 1938—Two females, one adult and one juvenile, taken in the scallop dredge 6-7 metres in d'Entrecasteaux Channel, Tasmania.  
 25 January 1939—One juvenile dredged at Jervis Bay, depth ?.

OCTOPUS CYANEA Gray 1849

- Octopus cyanea* Gray 1849, Cat. Ceph., 15, Port Jackson, N.S.W.  
*Distribution*—East coast Australia, etc.  
 14 September 1939—One small female specimen from Gunnamatta Bay. The common Sydney octopus.

# MISCELLANEOUS ADDITIONS TO THE ACARINE FAUNA OF AUSTRALIA

By H. WOMERSLEY, F.R.E.S., A.L.S., South Australian Museum

## Summary

Family CHEYLETIDAE Leach 1914  
Genus MYOBIA v. Heyden 1826  
von Heyden 1826, Oken, Isis, xix, col. 613.

MYOBIA MUSCULI (Schränk 1781)  
Schränk, F. v. P., 1781, Enum. Ins., Austriae. (Fig. 1, A-B)  
A number of specimens from a white mouse, McMaster Laboratory, Sydney,  
3 January 1942 (H. B. Carter).

MYOBIAA FFINIS Poppe 1896  
Poppe, S. A., 1896, Zool. Anz. (Fig. 1, C)  
A few specimens with the preceding from a white mouse, McMaster Laboratory, Sydney, 3 January  
1942 (H. B. Carter). The seven species of this genus now known to occur in Australia may be keyed  
as follows :



## MISCELLANEOUS ADDITIONS TO THE ACARINE FAUNA OF AUSTRALIA

By H. WOMERSLEY, F.R.E.S., A.L.S., South Australian Museum

[Read 11 June 1942]

## PLATE III

## Family CHEYLETIDAE Leach 1914

## Genus MYOBIA v. Heyden 1826

von Heyden 1826, *Oken, Isis*, xix, col. 613.

## MYOBIA MUSCULI (Schrank 1781)

Schrank, F. v. P., 1781, Enum. Ins., Austriae.

(Fig. 1, A-B)

A number of specimens from a white mouse, McMaster Laboratory, Sydney, 3 January 1942 (H. B. Carter).

## MYOBIA AFFINIS Poppe 1896

Poppe, S. A., 1896, Zool. Anz.

(Fig. 1, C)

A few specimens with the preceding from a white mouse, McMaster Laboratory, Sydney, 3 January 1942 (H. B. Carter). The seven species of this genus now known to occur in Australia may be keyed as follows:

- |   |  |                          |
|---|--|--------------------------|
| 1 | Tarsus II furnished with two claws.  | 3                        |
|   | Tarsus II with only a single claw.   | 2                        |
| 2 | Dorsal setae 2.2.4.4.2.4, first two broadly leaf-like.   | <i>musculi</i> (Schrank) |
|   | Dorsal setae 0.2.4.4.2.2, not as above.  | <i>minima</i> Wom.       |
| 3 | Tarsus III furnished with two claws.   | 5                        |
|   | Tarsus III furnished with only a single claw.  | 4                        |
| 4 | Dorsal surface posteriorly with three pairs of lancet-like setae differing from the remainder.           | <i>ensifera</i> Poppe    |
|   | Dorsal surface posteriorly with two pairs of setae, not differing from the rest.                         | <i>affinis</i> Poppe     |
| 5 | Short squat species. Dorsally with three pairs of long slender setae.                                    | <i>chalinolobus</i> Wom. |
|   | Elongate species. Dorsal setae otherwise.  | 6                        |
| 6 | Dorsal setae 4.4.2.4.4.2, very broad basally, especially the anterior rows, and longitudinally striated. | <i>miniopteris</i> Wom.  |
|   | Dorsal setae 4.4.2.4.2.2, not very broad basally.  | <i>clara</i> Wom.        |

## Genus CHELETOGENES Oudemans 1905

Entom. Bericht, 1905, 208.

## CHELETOGENES ORNATUS Canest. and Fanzago 1876

For synonymy see Oudemans 1906, Mem. Soc. Zool. Fr., 19, 133.

(Fig. 2, A-B)

The following record of this species was inadvertently missed from my paper of 1941 (Rec. S. Aust. Mus., 7, (1) ), and in the key to genera *Cheletogenes* was cited as not occurring in Australia.

A single specimen sent by Mr. S. L. Allman and found in galls on a fig, at Lismore, New South Wales, 7 June 1934, is of this species.

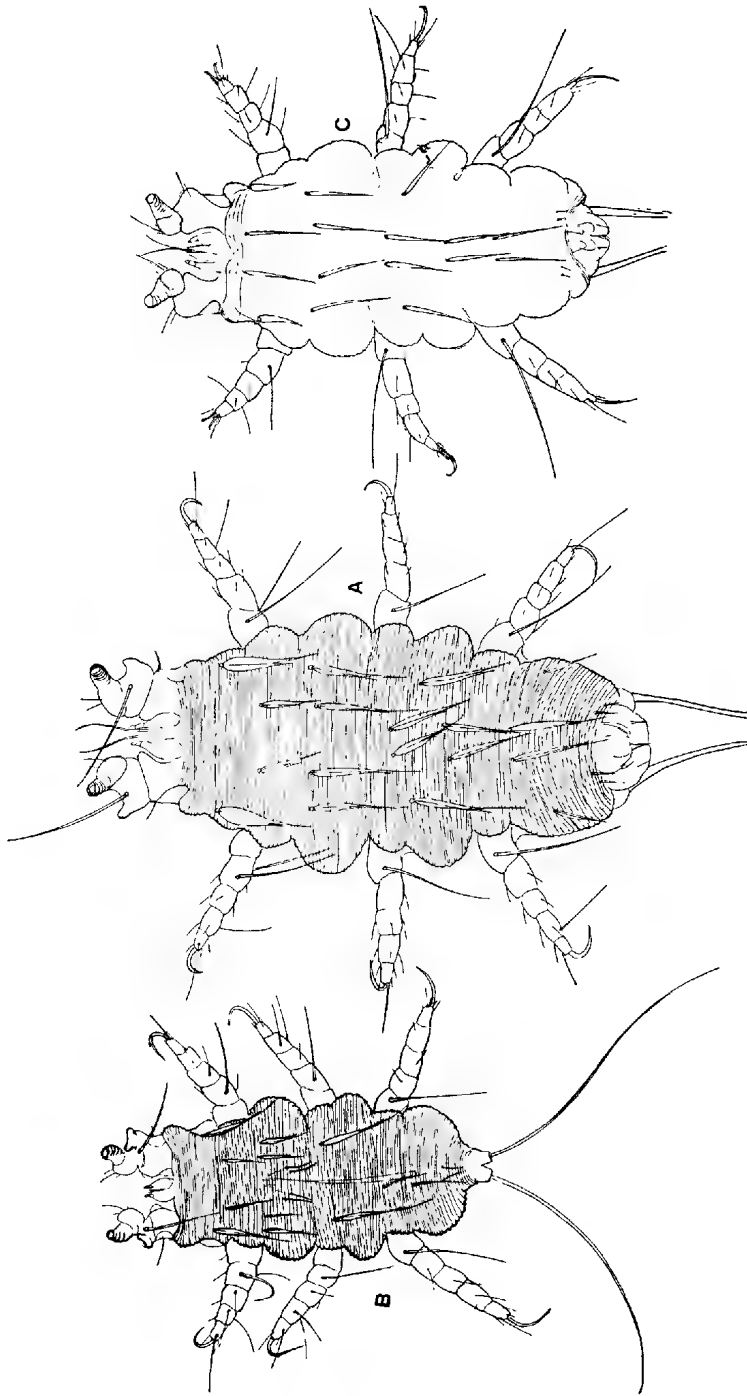


Fig. 1 A-C—A, *Myobia musculi* (Schrk.), dorsal view of ♀; B, same of ♀; C, *Myobia affinis* Poppe, dorsal view of ♀.

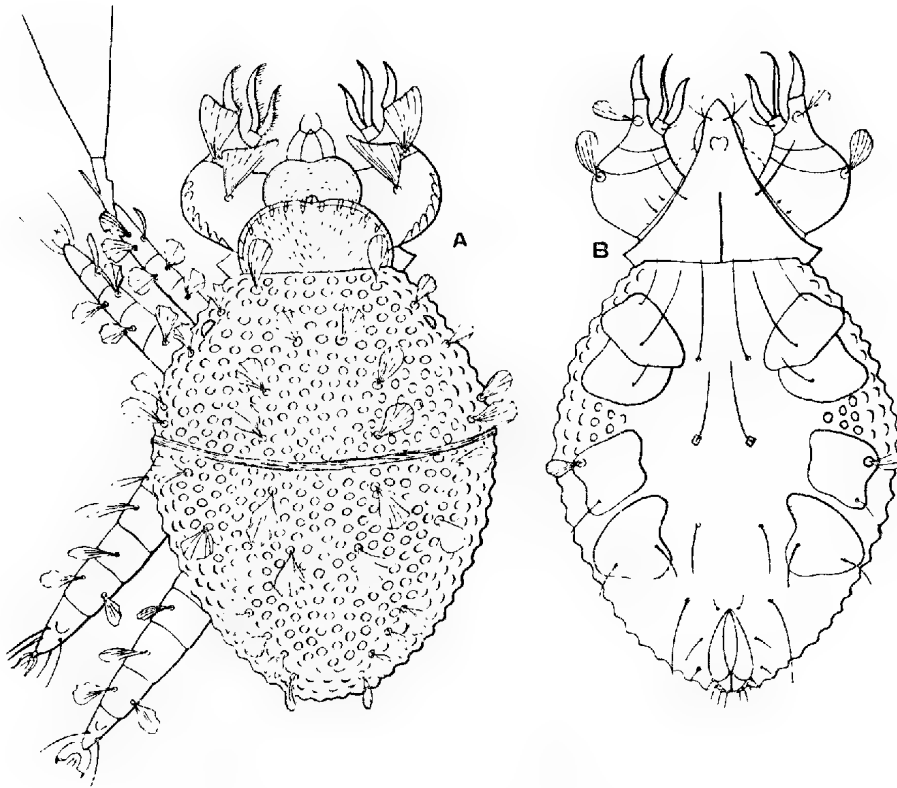


Fig. 2 A-B—*Cheletogenes ornatus*: A, dorsal; B, ventral.

Family TETRANYCHIDAE Dufour 1832

Ann. Sci. Nat., 25, 276-283.

Genus SEPTANYCHUS MacGregor 1919

Proc. U.S. Nat. Mus., 1919, 56, 663.

SEPTANYCHUS TUMIDUS (Banks 1900)

*Tetranychus tumidus* Banks 1900, Tech. Bull. No. 8, U.S. Dept. Agric., 73.  
*Septanychus tumidus* MacGregor, 1919, Proc. U.S. Nat. Mus., 56, 663.

This American species has been sent to me by Mr. R. T. M. Pescott as affecting Buffalo grass, *Stenotaphrum dimidiatum* (L.) Brogn., on a lawn at Melbourne, Victoria, in February, 1942. For the very interesting photograph of the webbing (pl. iii) of this species of "Red Spider" I am indebted to Mr. L. W. Miller.

Family TRICHADENIDAE Oudemans 1938

Genus RAOIELLA Hirst 1924

Hirst, S., 1924, Ann. Mag. Nat. Hist., (9), 14, 522, pl. xvi, fig. 1-6.

In Trans. Roy. Soc. S. Aust., 64, (2), 264, 1940, I described *Raoiella australica* n. sp., from the leaves of eucalypts in New South Wales and Queensland. I am now able to add a second Australian species, also from Queensland.

(Fig. 3, pl. I)

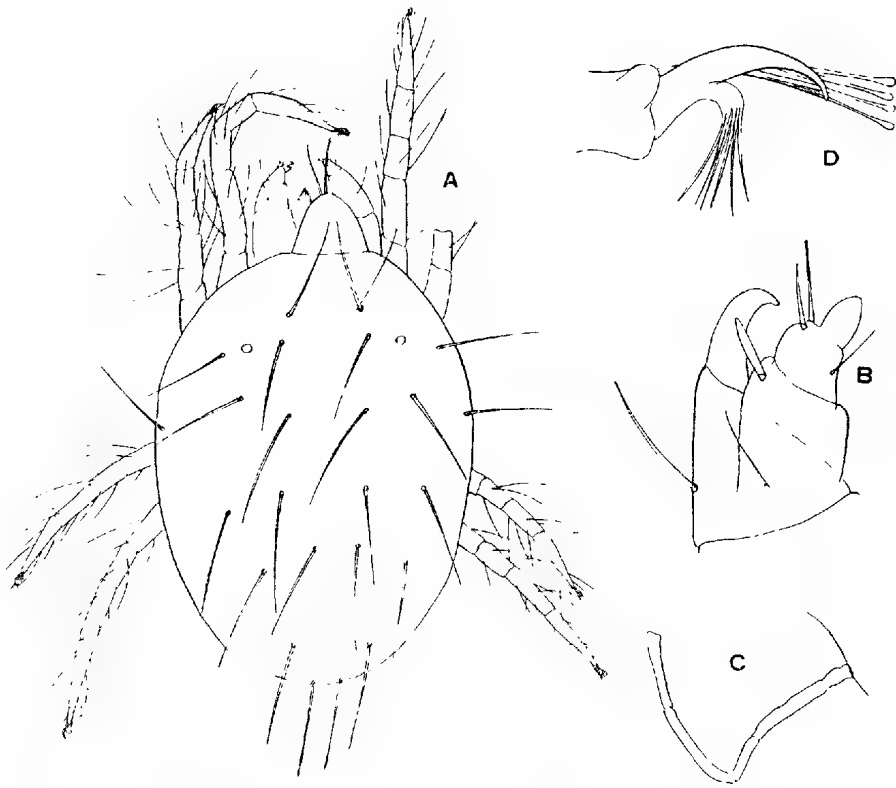


Fig. 3 A-D—*Septanychus tumidus* (Banks): A, dorsal view; B, tip of palp, showing tibia, claw and tarsus; C, peritreme; D, claw of leg II.

***Raoiella queenslandica* n. sp.**

(Fig. 4, A-E)

*Description*—Colour in life probably greenish. Length of ♀ 225  $\mu$ , width of ♀ 148  $\mu$ , hysterosoma as wide as propodosoma and evenly rounded posteriorly. Length of ♂ 190  $\mu$ , width across propodosoma 95  $\mu$ , hysterosoma tapering posteriorly. Eyes two on each side. Mouthparts piercing suctorial. Palpi 2-segmented, without tibial claw. Legs short with paired claws, each with two lateral tenent hairs, empodium with two series of tenent hairs as in genus; tarsi I and II with a strong thick rod-like sensory seta. Cuticle dorsally striated, as figured. All dorsal setae long and slender, finely ciliated, not apically clavate as in *R. australica*, Peritremata as figured. Penis of ♂ long and slender, as figured.

*Locality*—From *Eucalyptus micrantha* from Redland Bay, Queensland, 3 September 1941 (A. R. Brimblecombe).

Family ANOETIDAE Oudemans 1904

Entom. Bericht. 1904, 1, (1), 191.

Genus HISTIOSTOMA Kramer 1876

Arch. Naturges., 1876, 42, (1), 105.

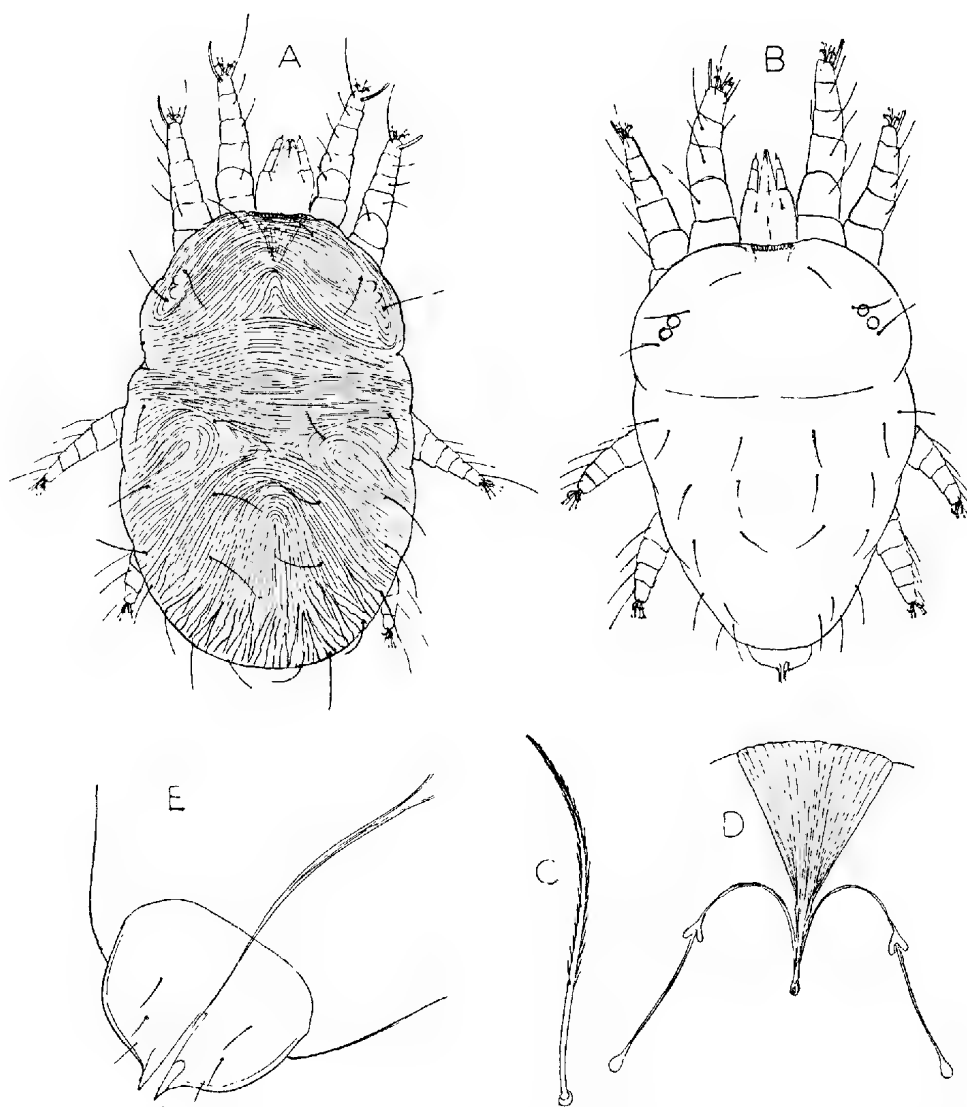


Fig. 4 A-E—*Raoiella queenslandica* n. sp.: A, dorsal view of ♀; B, dorsal view of ♂; C, dorsal seta; D, peritreme; E, penis of ♂.

HISTIOSTOMA HUMIDITATUS (Vitzthum 1926)

*Anoetus humiditatus* Vitz. 1926 (1927). "Acarologischen Beobachtungen," Reche. Sitz. Ber. Gess. Naturf. Fr., Berlin, 98.

(Fig. 5, A-F)

Vitzthum described this species from the female only, from pine-needles from Lower Austria.

It has now been found in numbers on the roots of tomato plants grown in nutrient solution by Mr. S. L. Allman, at Ryde, New South Wales, 22 September 1941.

From the material submitted to me for study by Mr. Allman, it is now possible to figure and describe the male and the deutonymphal stage.

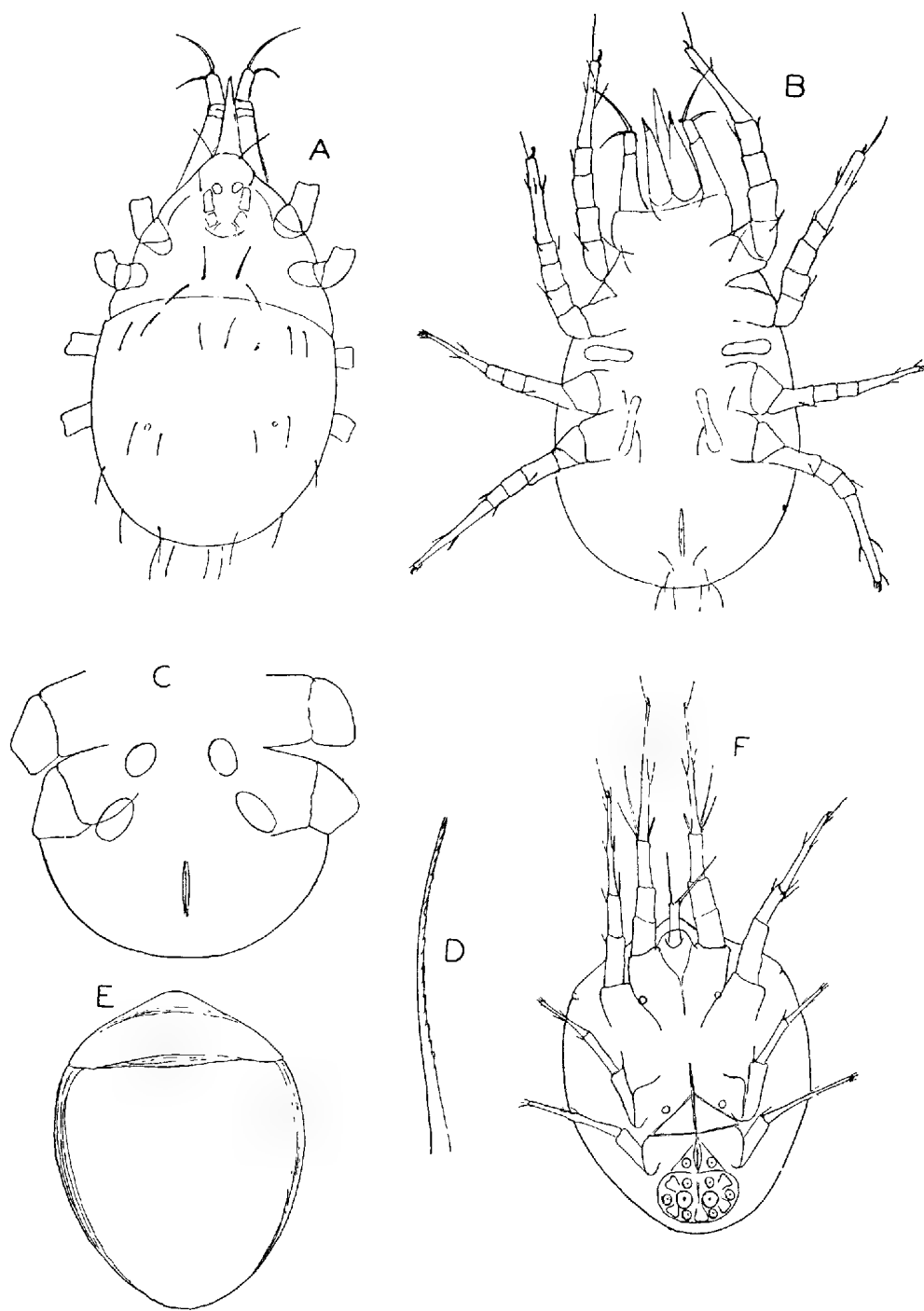


Fig. 5 A-F—*Histiotoma humiditatus* Vitz.: A, dorsal view of ♀ ; B, ventral view of ♀ ; C, ventral view of ♂ , posterior half ; D, mandibular appendage ; E, dorsal view of deutonymph ; F, ventral view of deutonymph.

*Description—Female:* Length to 310  $\mu$ , width to 190  $\mu$ . Gnathosoma distinctly visible from above in front of propodosoma. Palpi 2-segmented the segments not expanded laterally, with two long apical curved setae, the outer of which is directed backwards. Mandibles with long serrated, "augur-like" process (fig. 5 D). Propodosoma somewhat triangular, hysterosoma broadly rounded, both without raised bosses. Dorsal setae fine and arranged as figured. Legs normal as for the genus. Ventrally the two pairs of pores are "sole"-shaped, being two to four times as long as wide; one pair is between coxae III and IV and lies horizontally, the other pair is longitudinal and lies inside coxae III and IV. *Male:* As in female, length 190  $\mu$ , width 100  $\mu$ . Ventrally the two pairs of pores are shortly oval, and both lie between coxae IV (fig. 5 C). *Deutonymph* (fig. 5 E, F). Length 160  $\mu$  width 130  $\mu$ . Dorsally with distinct suture between propodosoma and hysterosoma, apparently without setae. Ventrally as figured with paired discs between coxae I and II, and on coxae III. Suctorial plate with eight discs, median pair larger than the rest; another disc on each side of vulva.

Genus **Chiropteranoetus** n. g.

*Deutonymph*—As in *Anoetus* but disc on coxae I replaced by a strong blunt spine-like process, no disc or process but a normal spine on coxae III, suctorial disc with two large discs, on each side of which is a short blunt spine-like process, and the two posterior discs also replaced by spine-like processes; a spine-like process on each side of vulva. Legs relatively long with fairly strong spines, tarsi I, II and III with single claw, IV without claw but with two apical setae not as long as tarsus.

Dorsally with a pronounced gnathosomal projecting plate; with strong suture between propodosoma and hysterosoma; dorsal setae long and fine. Eyes absent. Genotype **Chiropteranoetus chalinolobus** n. sp.

**Chiropteranoetus chalinolobus** n. sp.

(Fig. 6, A-B)

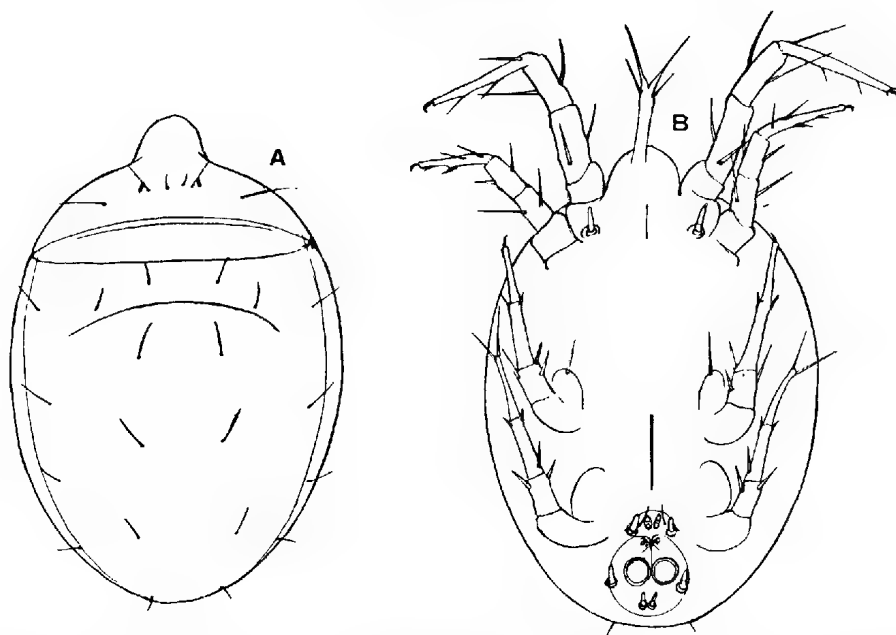


Fig. 6 A-B—*Chiropteranoetus chalinolobus*: A, dorsal, legs omitted; B, ventral.

*Description*—*Deutonymph*, length 300  $\mu$ , width 195  $\mu$ . Dorsally on propodosoma with six fine setae, the median pair being the shortest; on hysterosoma setae arranged 6.4.4.4.2, length of setae 18  $\mu$ . Adult unknown.

*Locality*—A single specimen from residue in jar containing bats (*Chalinolobus gouldi*), M 503-5, 507, 453, 532, probably South Australia.

Family PONTOPPIDANIIDAE Oudemans

Entom. Bericht, 1, (7), 1927, 244.

Genus CALVOLIA Oudemans 1911

Entom. Bericht, 1, (3), 1911, 187.

CALVOLIA ? HETEROCOMUS (Michael 1903)

*Tyroglyphus heterocomus* Michael 1903 (in part), Brit. Tyrog., 2, 106, pl. xxxiii, fig. 4-5.

(Fig. 7, A-B)

*Deutonymphs*—Length 215  $\mu$ , with 170  $\mu$ , of what is probably the above species, have been sent to me for study by Mr. Tarlton Rayment. They were found on *Prosopis* sp. at Borrooloola, Victoria.

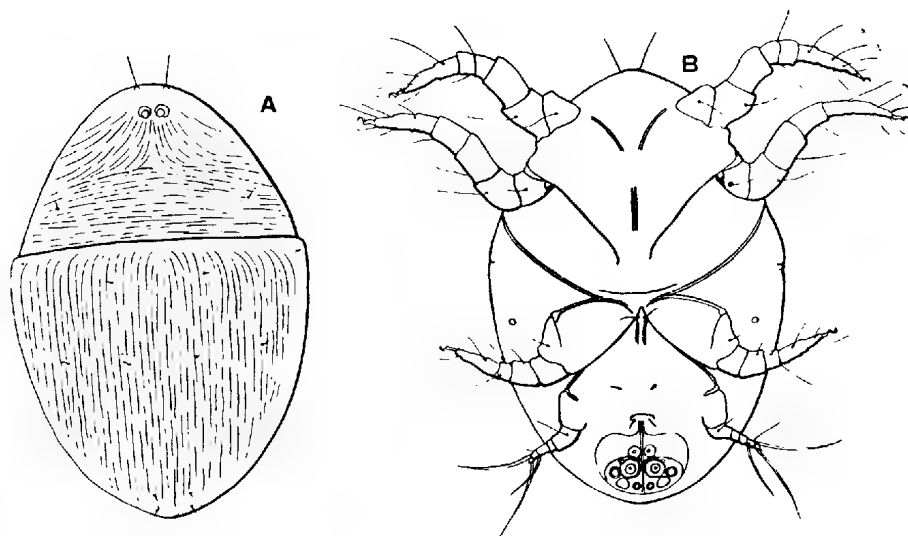


Fig. 7 A-B—*Calvolia* ? *heterocomus* (Michael): A, dorsal, legs omitted; B, ventral.

Family ANYSTIDAE Oudemans 1902

Genus CHAUSSIERIA Oudemans 1937

Zool. Anz. 120 (3/4).

In the Zoologischer Anzeiger (*loc. cit.*) Oudemans changes his generic name *Schellenbergia* 1936 to *Chaussieria* on the grounds of pre-occupation by von Heer 1865 for an arachnid. The species *Schellenbergia warregense* (Hirst) re-described by me (this Journal, p. 20) must therefore be renamed *Chaussieria warregense* (Hirst).





Webbing of *Septanychnus tumidus* (Bks.) on Buffalo Grass,  
Melbourne, Victoria.

Photo by L. W. Miller

# **ABORIGINAL NAMES AND USES OF PLANTS IN THE OOLDEA REGION, SOUTH AUSTRALIA**

By T. HARVEY JOHNSTON and J. BURTON CLELAND, University of Adelaide

## **Summary**

In August 1939 a visit was paid to Ooldea, under the auspices of the Board for Anthropological Research, University of Adelaide. We desire to acknowledge assistance received from Messrs. H. Green and A. G. Mathews of the United Aborigines Mission at Ooldea. Our information was derived from various tribesmen, some of them associated with the Mission Station, whilst others were nomads. The ecology of this extremely interesting region where the sandhill country and the great Nullarbor Plain meet, has been studied by Adamson and Osborn (1922). The systematic botany of the district, as well as of adjacent areas, was reported on by Black (1917 a), who also published a vocabulary of the Wirrung people from Murat Bay (1917). Mrs. Daisy Bates, in her vocabulary of the Wirrung people (1918) from the adjacent region of the Great Australian Bight, mentioned a number of native names relating to the fauna and flora, and also gave some information in her account of "Ooldea Water" (1921).

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[Read 11 June 1942]

In August 1939 a visit was paid to Ooldea, under the auspices of the Board for Anthropological Research, University of Adelaide. We desire to acknowledge assistance received from Messrs. H. Green and A. G. Mathews of the United Aborigines Mission at Ooldea. Our information was derived from various tribesmen, some of them associated with the Mission Station, whilst others were nomads. The ecology of this extremely interesting region where the sandhill country and the great Nullarbor Plain meet, has been studied by Adamson and Osborn (1922). The systematic botany of the district, as well as of adjacent areas, was reported on by Black (1917a), who also published a vocabulary of the Wirrung people from Murat Bay (1917). Mrs. Daisy Bates, in her vocabulary of the Wirrung people (1918) from the adjacent region of the Great Australian Bight, mentioned a number of native names relating to the fauna and flora, and also gave some information in her account of "Ooldea Water" (1921).

The presence of permanent water at the Soak (Yuldi, native name for Ooldea) has led to the locality becoming an extremely important centre for native visitation, bartering and ceremonial, aborigines visiting it from distant regions lying west, east and north. The importance of Ooldea in these connections has been referred to by one of us (Johnston, 1941). Though originally occupied by the Wirrung tribe, its chief inhabitants are the Andigerri from the sandhill country to the north and from the Everard Ranges, but tribesmen from the far north-west, even from the Warburton Ranges in Western Australia, are also to be met with there. Few Wirrung were present during the time of our visit. In view of these facts, it is not surprising that many of the names we obtained for plants are similar to those received in the Musgrave Ranges, as well as to those published by Helms (1896), who accompanied the Elder Expedition. The latter traversed the northern and western portion of the great desert from the Everard Ranges, Blyth Ranges, south to the Fraser Range, and Helms has given short vocabularies of the peoples met with, the lists of words including many relating to the fauna and flora. Those referring to the flora have been mentioned in our paper dealing with the ethnobotany of the Musgrave Range region. (Cleland and Johnston, 1937, 1938).

The order of arrangement of the plants mentioned in this paper is that given by Black in his Flora of South Australia (1922, 1924, 1926, 1929), and we have, in most cases, omitted authors' names. Mr. Black kindly supplied us with some native names collected by him when at Ooldea some years ago, and has identified some plants regarding which we were in doubt.

Black (1917), in his Wirrung vocabulary, published the following names relating to the plants:—bluebush (*Cratystylis conocephala*), bududu, bundera, burunda; *Trichinium incanum*, bunjuru; saltbush (*Atriplex Muelleri*), bunjuru; *Myoporum brevipes*, djindidji; *Helipterum floribundum*, djindidji; *Pholidia Weldii*, (= *Eremophila Weldii*) djindijn. He commented on the fact that the same name was applied to quite different plants, and went on to say that it appeared that the natives' power of discrimination was not great as regards vegetation which was of no practical use to him. We suggest that, in some cases, the term used applies to some attribute which is common to such plants, just as the word tjilka (djilka), which means prickly, has been received by us as the name of a wide variety of plants; or okiri (ugiri) for various green and somewhat succulent forms. If a

plant is used by natives for a food (either as seeds, fruits, flowers, leaves, roots), for making implements, for decoration, or for ceremonial purposes, etc., then it has a name; if not, then it receives no more attention than would be given to it amongst ordinary white people. Black's term *djindiji* applied to several plants is suggestive of *jinda-jinda* given by Basedow (1904) as a general term for flower in north-western South Australia, the same name *djinta-djinta* having been obtained by us (1937) for flowers, e.g., the flowering head of *Myriocephalus Stuarti*, in the Musgrave Ranges. Black's name *jilba* for *Solanum hystrix* suggests the term *djilka* (prickly) already referred to by us.

Other Wirrung names for plants quoted by Black (1917) are *Mesembryanthemum aequilaterale*, *wilbelbi*, *wildalbi*; *Tetragonia implexiconia*, *walbelbi* (apparently the same name as for the preceding); *Acacia notabilis*, *mi-na* (we received this name for several shrubs until the natives pointed out to us that it referred to bird nests which we had not noticed in them); *Nitraria Schoeberi* *wanjeri*, whose berries are edible; *Zygophyllum Billardieri*, *merkaltji*; *Melaleuca parviflora* (= *M. pubescens*), *karo*; *Eucalyptus incrassata* var. *dumosa*, the common mallee near Murat Bay, *gi-lja*, *ki-lja*; *Alyxia buxifolia*, *ping-gjeli*; *Westringia Dampieri* *kunbudn*; *Solanum coactiliferum*, *kumba*. Amongst the more general terms mentioned by him in his Wirrung vocabulary are:—leaf, *kalbi*; food, *ma*; water from the roots of a mallee, *nga-ru kabi* (since the latter term means water, *nga-ru* is the name of the tree; we obtained *nga-barri* as the name of the chief water-bearing species at Ooldea); berry, *tata*; *wurley*, *ngu-ra*.

Mrs. Bates' Wirrung vocabulary (1918) was apparently based largely on her contact with natives near Fowler's Bay, south of Ooldea. Few of the names in it relating to plants are associated with definitely identified species, and we have added our comments in square brackets. *Anguillaria dioica*, *gibera ma*, i.e., turkey food, *gibera* = wild turkey [*Eupodotis australis*], *ma* = plant food as distinct from *baru* or *ku-ga* meaning animal food. A species of she-oak [*Casuarina lepidophloia*], *kurli*, *gurli*. *Loranthus* [*L. miracularis* var. *Boormanii*] parasitic on sandalwood [*Myoporum platycarpum*], *miljiling*, fruit edible. Saltbush [*Atriplex Muelleri*] *mambululu*. *Mesembryanthemum* sp., *kargala*. *Pittosporum phillyraeoides*, *kundelu*. *Acacia* sp. *myall*, [*A. Sowdenii*], *kardia*. *Acacia* sp., *bu-nidi* [this name is applied widely to *Cassia phyllodinia*], *Acacia* sp., *walduri*, its edible gum being called *dauw* [*walduri* is applied at Ooldea to *A. oswaldii*]. Native currant, *wanjiri* [Black (1917) gave this name for *Nitraria Schoeberi*]. *Melaleuca* sp. [*M. pubescens*], *karu*. A species of mallee, *djindu*. Mallee with water-bearing roots, latter termed *birli* or *ngari* [*Eucalyptus oleosa* var. *Peenari*]. Red mallee, *jagala*. Mallee, the bark of whose root is edible, *kong-u* or (in Eucla district) *nala*. *Solanum* sp., fruit is *kumba* [Black (1917) gave this name for *S. coactiliferum*]. *Solanum* sp., a small prickly species, fruit is *walga* (probably *S. hystrix*). Native gooseberry [*Solanum ellipticum*] *gujana*. Sandalwood [*Myoporum platycarpum*] *bulgara*; its gum (*kandi*) was used for fastening flints on implements. *Myoporum* sp. *djindidji* [this term was given by Black (1917) for *M. brevipes*]. *Pholidia scoparia* [*Eremophila scoparia*] *walgala*. Green edible mushroom, *dhamuna*. Red fungus found on dead sandalwood [*Trametes cinnabarica* on dead *Myoporum platycarpum*]. Various edible fruits, not identified, were termed *kalgula*, *karambi*, *mindara*, *njilba*, *tjurguin* (a small white fruit). Edible fruits were *tjugarn* (like a parship) [probably *Boerhavia diffusa*], *kagu* and *djungu-djungu*. *Wongonu* was applied to small seeds (? *nardoo*) pounded and made into damper [this term is applied to all small seeds, e.g., of grasses, which are so treated]. Other terms are *jilgi*, a bed made of leaves, grass, etc.; *ngura*, a *wurley* or hut of boughs (*joo*) and saplings; *warda*, shrub; *kala warda*, fire-wood (*kala* = fire). Wooden implements include *ju-jan*, a spear made from a root and hartered from a region in Western Australia; *kadjji*, spear; *kali*,

boomerang; windu, a hooked twig used for picking out edible grubs (mo-gu, dji-rigi, jalgundu) from roots.

In a paper dealing with "Ooldea Water" Mrs. Bates (1921) mentioned boorn-boorn (quandongs), dharrulga (mulga apples), nyurongil (parakylia [*Calandrinia*]) as edible foods; ugiri, native tobacco (the "pitchuri" of Spencer and Gillen) brought down by northern tribes for barter; kooli (she-oak); walgala (a broombush); saltbush and bluebush (mambula); a water bush growing round the Soak (wilbala) [*Melaleuca* and *Leptospermum*]; ngabbari (mallee); and ngalda (mallee with water-bearing roots).

We have arranged our observations according to the families to which the plants belong.

#### PINACEAE

*Callitris verrucosa*, middurtu. Its gum (girrdi, middurtu girrdi) is used for attaching parts of weapons, and for fixing the flint (kandi) to the spear-thrower (meru). Helms (1896, 320) recorded the same name (medurtu) from the Blyth Range, miduru (324) from Fraser Range, and medduru (325) from Hampton Plains.

#### SCHEUCHZERIAACEAE

*Triglochin centrocarpa*, nim-ba-lba, o'kiri, o-giri. The latter terms are applied to various low-growing green plants.

#### GRAMINEAE

*Paspalidium jubiflorum*, karra garra. The same term was obtained for *Stenopetalum lineare*. Helms (1896, 320) stated that the term kara which is associated with some plants, e.g., *Aristida arenaria* (putta kara, putta = grass), in the Blyth Range, probably means cough or vomit.

*Stipa* sp., wang-u. Seeds utilised as food. Flower stems used by children as play spears. Helms (320) obtained the same name for spinifex (*Triodia*) seed and for young plants, and stated that it probably was employed as a term for all kinds of seeds.

*Triodia irritans*, goolbarra. Bolam (1925, 51) mentioned that there were two kinds of spinifex, one kind edible by stock, and the other "porcupine grass" of little value; and that from the latter (51) the natives extracted a resin with which they attached the heads of spears to the shafts. He referred to the method of using the material (86). He also mentioned that water from cavities in trees was sucked up through a hollow spinifex stalk.

*Eragrostis Clelandii* S. T. Blake, wangu, wanganu, wonganu. Seeds ground and made into a damper (ngu-ma). Damper made with white man's flour is called damper and not ngu-ma. Mai-i is a general term for plant food. Helms (1896, 320) recorded wangu for *E. eriopoda*. Bates (1918, 160) gave wonganu as the Wurrung name for a small seed (regarded as ?nardoo) which was pounded and made into damper. The seed is much more likely, in the Ooldea region, to be that of grasses.

#### LILIACEAE

*Lomandra leucocephala*, iria. Flowering stem placed in the hair as a decoration.

*Thysanotus exiliflorus*, tjipari. Long, tuberous, rather watery, root eaten, the taste being slightly bitter and somewhat like that of raw potato. Bolam (1925, 50) stated that natives obtained water from the long thin bulb on the root of a particular kind of grass called joonga joonga; that this bulb, two to three inches long, was very juicy and was eaten raw or roasted; and that it grew in dry sandy areas. Bates' term (1918, 154) djungu djungu for an edible root obviously belongs to the same plant. We believe that both authors were referring to *Thysanotus*.

## CASUARINACEAE

*Casuarina lepidophloia*, goorli, kurli. Bolam (50) published a photograph of the tree (kooli) and stated that its roots were water-bearing. Magarey (1895, 650-651) referred to Tietkens' experience of the oak in the Ooldea region as a supply of potable root water.

*Casuarina Decaisneana*, the desert oak of the region lying northward from Ooldea. Magarey (1895, 652) referred to the use by natives of water collected in hollows at the forks of this tree, Bolam (1925, 50) mentioning that a spinifex stalk was sometimes used for sucking up such water. The latter author stated that shields were made from the oak (presumably *C. lepidophloia*) and gave an account of their manufacture (84).

## PROTEACEAE

*Hakea multilincata*, yuldi-nga; this is the native name for Ooldea. Helms mentioned yundinga (pl. 27) and yindinga (pl. 15, fig. 1) as head ornaments (322, but the terms may not be related to that given by us. Water was obtained at Ooldea from the surface roots which, after having been pulled up, are broken into pieces 9 to 12 inches long, the bark removed (with the teeth) from one end, and the pieces held with that end downwards to allow the water to drain.

*Hakea leucoptera*, urrbi. Its roots also afford an important supply of water. Magarey (1895, 650) referred to it.

*Grevillea stenobotrya*, yeraing. It often has an edible grub (ma-gu, ma-ku) in its roots.

*Grevillea Hugelii*, orrbi, urrbi.

## SANTALACEAE

*Eucarya acuminata* (quandong), toordoo. Fruit roasted when green and then eaten. Kernel of ripe fruits eaten. Bates (1918, 15) gave the name kurdi for the tree and burn burn (154) for the fruits. Mr. Black obtained the latter name for the fruits of this species as well as *E. murrayana*. Helms (318) gave bunbun as the name in the Everard Ranges. The light wood is used in making fire. A small branch or stem is partly split and the crevice filled with dried grass or leaves or very soft wood or dung, all of these being objects capable of smouldering. A piece of hardwood or a harder piece of quandong, shaped to a fairly sharp firm edge, is used as a saw, which is moved rapidly across the larger piece of wood, the resulting heat causing smouldering of the tinder. Bolam (1925, 88) mentioned as requisites, some fine grass, a very dry piece of quandong, a sharpened piece of hardwood and some dry animal manure.

*Eucarya murrayana*. Mr. Black, in a letter, informed us that burn burn was applied to its fruits at Ooldea.

*Eucarya spicata* (sandalwood), pu-lara, bulara. Fruits not eaten. Mr. Black obtained the name bulgar. Helms (1896) received the latter name from the Fraser Range (p. 323) and Hampton Plains (p. 325) for the false sandalwood, *Myoporum platycarpum*.

## LORANTHACEAE

*Loranthus miracularis* var. *Boormani* Blakely from *Myoporum*, barraka barraka; ngun-dji. These names are applied to any mistletoe. We obtained njingni as the name in the Musgrave Ranges (Cleland and Johnston, 1937). The term barruga means foliage, the duplication indicating, no doubt, the characteristic dense and strikingly coloured foliage of the plant. Bates (1918, 157) gave mil-jiling for *Loranthus* with edible fruit and parasitic on sandalwood, the reference probably being to the species just mentioned by us.

*Loranthus quandong*, manni manni. Same term obtained for *Dicrastylis*.

## CHENOPODIACEAE

- Chenopodium microphyllum*. No name available.  
*Bassia obliquicuspis*, pilka pilka (not djilka djilka).  
*Bassia humiflora*, djilka djilka.  
*Kochia triptera*, kalaia-la, i.e., emu (kalaia) food.  
*Kochia sedifolia*, pundtharra, pundtarra.  
*Arthrocnemum halocnemoides*, walkidi.  
*Salsola kali*, djilka-la, djilka djilka (prickly).

## AMARANTACEAE

- Trichinium alopecuroideum*, windalura.  
*Trichinium obovatum*, purar-purar. Same name obtained for it (syn. *Ptilotus obovatus*) by Helms (1896, 320) in Blyth Range.

## PHYTOLACCACEAE

- Gyrostelemon ramulosus*, guru maru, kuru maru. (guru = eyes; maru = black—name applied apparently on account of the small black eye-like knots exposed when branches fall off).  
*Codonocarpus cotinifolius*, kaloordi. Stem and roots commonly invaded by a small edible grub (ma-gu).

## AIZOACEAE

- Carpobrotus aequilateralis* (syn. *Mesembryanthemum aequilaterale*), nyoorn-geee.

The same name was obtained for a *Calandrinia*. According to Mr. H. Green of Ooldea, it is also applied to the water-holding frog (nyarnn-geee), and the term suggests niurni quoted by Helms (1896, 324) for *Dianella revoluta* in the Fraser Range. Bates (1918, 156) gives kargala as the Wirrung name for the pigface (*Mesembryanthemum*). The flowers are used in a man's head-band as an ornament.

- Tetragonia expansa*, loru-leru.

## PORTULACACEAE

- Calandrinia polyandra* (probably), wakadi, edible. The same term was obtained by us (1937) for *C. volubilis* in the Musgraves.  
*Calandrinia disperma*, ngurn-ngni. Same name given for *Carpobrotus* (*Mesembryanthemum*).

## CRUCIFERAE

- Lepidium oxytrichum*, ogiri.  
*Stenopetalum lincare*, karra garra, kara-kara. Same name given to a panic grass. Mr. Black obtained the name arawin for this plant in 1920.  
*Stenopetalum velutinum*. Mr. Black received unmurdu as its name. We obtained unmuta for it (1937) in the Musgrave Ranges.

## PITTOSPORACEAE

- Pittosporum phillyreoides*, ali-di. Bates (1918, 157) recorded kundelu as its Wirrung name.

## LEGUMINOSAE

- Acacia colletioides*, goordil-goordil.  
*Acacia Kempeana*, ilgu-ara. Helms (1918, 318) gave the same name (ilguarra) for the mulga in the Everard Ranges.  
*Acacia Sowdenii* (myall) kardaia. Bates (1918, 156) gives kardia. The wood is used extensively for making boomerangs (kali = curved), heavy waddies, womerabs, and heavy spears.

*Acacia Oswaldii*, waldari. Wood used for making boomerangs. Bates (1918, 154) gives dauw as the Wurring name for the edible gum of walduri, a species of *Acacia*.

*Acacia Randelliana*, murru.

*Acacia brachystachya*, buggu-da, baguda, bugata. Mulga apples (dharrulga) caused by a hymenopteron, are eaten raw. The tree is commonly infested by the larva of a bag moth, the large silky bag being termed wang-ga. The twigs and leaves of the tree supply the ash (purrgu) for use with *Nicotiana* (pulandu) as a chewing-narcotic. The needle-like leaves of the acacia are chewed to make saliva flow more freely for use in mixing red (tur-tu) and white (pi-anba) ochre on a piece of mallee bark or in a wooden or bark dish (wirra), the mixture being utilised for decorating the body for ceremonial occasions. The leaves are chewed and the resulting saliva is added to wood shavings from the same plant, and then rubbed up in the hands along with ashes from the camp-fire to produce a silvery green colour for decorating headbands. The plant is used extensively in connection with the inma-thali (inma = ceremony; thali or tjali = wreath or ring-like pad), mention of which will be made later in this paper.

*Acacia aneura* (mulga), koorku, kurku. Is used extensively for making implements and weapons, e.g., digging sticks (wanna), waddies (toording), spears (kadji, katji), boomerangs (kali, kai-li), womerahs (meru), and rounded decorated waddies (doorna). Edible lac from mulga is termed maruka. Mulga apples (galls) are dharrulga or darulka.

*Acacia ligulata*, wadoolya, windulya, wadarraka.

*Acacia tetragonophylla*, koorara. Used for making small ceremonial objects. *Acacia* spp. Seeds ground, cooked and eaten. The gum (girrdi) is also eaten.

*Cassia phyllodinia*, poondi, boondi, bu-ndi. The shrub commonly has an edible grub (ma-gu boondi) in its roots. The foliage is sometimes used for making the main mass of the wreath for the inma-tjali ceremony. Helms (1896, 318) gives bundi for *Cassia desolata* in the Everard Ranges, and makobundi for the larva of a *Cossus* moth in the Blyth Range. Mrs. Bates (1918, 153) referred to bundi as a species of *Acacia*.

*Daviesia ulicina*, djilka djilka (= prickly).

*Clanthus speciosus* (syn. *C. Dampieri*), gu-ru darn, kuru-darn, i.e., staring eyes (guru = eyes) on account of the arrangement of the dark colouration in the flowers.

#### GERANIACEAE

*Erodium cygnorum*, ngumilba. Root cooked in ashes and then eaten.

#### ZYGOPHYLLACEAE

*Zygophyllum glaucescens*, ngee-wee, "horse feed." The term ngee may suggest succulence since it forms part of the name of *Mesembryanthemum*, *Calandrinia* and frogs (nyoorn-ngee).

*Zygophyllum ammophilum*, uraitja. Has a small edible grub in its root.

*Zygophyllum fruticulosum* var. *eremaea*, pai-yinda.

#### EUPHORBIACEAE

*Adriana Hookeri* (water bush), kapi kapi (ka-pi = water). Helms (1896, 320) gave the same name for *Cassia pleurocarpa*. *Adriana* has an edible grub (magu) in its roots. Mr. Black obtained the name kanba gura for the plant. Kanba or ganba is the name of the huge mythical snake of the Nullarbor Plain, and gura or guru means eye.

*Euphorbia Drummondii*, mimmi (= milk).

*Euphorbia eremophila*, mimmi.



## SAPINDACEAE

*Heterodendron oleifolium*, ta-lura, da-lura, taljura. Used for making light shields and boomerangs.

*Dodonaea attenuata*, djinning, tjinning. The leaves and branchlets may be used in making the pad or wreath (tjali) for the inma tjali. The bud-like male flowers are termed ka-ludi.

*Dodonaea viscosa*. Mr. Black informed us tjining is applied to this species as well as the preceding.

## THYMELEACEAE

*Pimelea microcephala*. Mr. Black obtained the name djildjarbi for this species at Ooldea. Mrs. Bates (1918, 154) stated that djildja means the calf of the leg.

## MYRTACEAE

*Leptospermum coriaceum*, winba-la, wilba-la. Flowers sucked to obtain the nectar (wom-a = something sweet; same name applied to sugar).

*Melaleuca pubescens*, karu, wilba-la. Bates (1918) also gives karu for tea-tree.

*Melaleuca uncinata*, karu.

Species of mallee (*Eucalyptus* spp). Digging sticks (wanna), spears, clubs and small dishes (wi-ra) may be made from any of the species, the three which are common at Ooldea being *E. oleosa*, *E. incrassata* (*dumosa*) and *E. pyriformis*. Bolam (1925, 83) has described the method of making spears by straightening long thin mallee stems in hot ashes and then trimming them with pieces of broken glass or with some iron implement. Where these accessories are not available, the original method of trimming by using the flint chisel of the spear-thrower would be employed. Black (1926, 418, 421) reported that *E. oleosa* was the "water mallee" at Ooldea; that *E. incrassata* and *E. dumosa* were water mallees in desert country, since natives were able to obtain a supply of water from the roots; and that the two latter were very closely related and that perhaps *E. dumosa* should be united with *E. incrassata*. We have used the latter name.

*Eucalyptus leptophylla*, midtyi, midtji.

*Eucalyptus oleosa*, nga-bari. The importance of the species as a supply of "root water" for aborigines in the arid region extending east, north and west from Ooldea has been emphasised by Johnston (1941, 34). Eyre was the first to report (in 1845) the value of the tree in the region north of the Bight. The method of obtaining the water has been described by Eyre (1845), Magarey (1895, 648), Bolam (1925, 49), Macpherson (1936, 177) and Cleland (1940, 8). The form growing at Ooldea is sometimes recorded as var. *transcontinentalis*, but Black (1926, 418) apparently did not consider varietal rank necessary. He has since informed us by letter that the Ooldea tree should be known as *E. oleosa* var. *Peenari* Blakely. Bolam published a photograph of the tree.

We observed that after breaking off and pulling up long lengths of surface roots and then breaking them into short pieces, 10-12 inches long, the bark was torn off each piece by using the teeth. Then one end was blown hard and water and bubbles appeared at the other, the water being astringent and pale brownish. After a study of the area of pore surface seen in transverse section of a root just under one inch in diameter, Cleland (1940, 9) reported that a piece little more than a yard in length could hold about four ounces of water, and that three roots each about 30 feet long and one inch in diameter could hold about one gallon.

The lerp which occurs on this and the other species of Ooldea mallees is edible and is termed woma (= sweet).

*E. oleosa* is called red mallee (Magarey 1895; Black 1926) because of the colour of its wood, but the same name is applied by the latter author to *E. leptophylla* and to one form of *E. gracilis*. Bolam speaks of it as the "brown bark"

mallee (ngalda). Bates (1918, 153, 159) gave the Wirrung names birli and ngaru for water-bearing roots of mallee, and called red mallee jagala (155), but was probably referring in the latter case to a species distinct from *E. oleosa*. Later (1921) she used the names ngabbari for mallee and ngalda for the mallee with water-bearing roots. Black (1921, 17) gave the terms nabbari or ngabbari for *E. oleosa* and mentioned that, further north, it was called nabbara or abbara.

MacPherson (1936, 177), in an article on the eucalypts in the daily life and medical practice of the aboriginal, called the water mallee at Ooldea *E. dumosa* (nabbari), and mentioned that during a funeral service mourners waved branches of this shrub about the grave and finally buried them at the foot of the grave with the body. A detailed account of the use to which grass, leaves and branches of (apparently) any locally convenient mallee are put in connection with the burial and reburial ceremonies, has been described recently by Berndt and Johnston (1942).

*Eucalyptus pyriformis*, yeldar-ba, djar-gula, djar-gala. Nectar (woma) is obtained from the flowers. The roots are not used as a water supply. Mr. Black obtained jaldar as the name of the tree and dardu-gula for the large fruit capsule, these names being similar to those received by us. Djar-gala is obviously Mrs. Bates' (1918, 155) jagala (=dja-gala) which she called a red mallee, though Black wrote of *E. pyriformis* as "Ooldea mallee."

*Eucalyptus incrassata* (including *E. dumosa*), bi-arr, bi-arb, bi-arba, pi-arpa, pi-arr. Branches and leaves used in ceremonials (inma). Capsules used as hair ornaments (djindjula). Wood of this white mallee used for spear-throwers and other wooden implements.

Helms gave the name Kararda (1896, 325) for it in the Fraser Range and Hampton Plains.

*Eucalyptus gracilis*. We did not observe this species at Ooldea. One form of it is a red mallee, and the other is a white mallee (Black 1926, 324).

Bates (1918, 156) gave kongu as the name of the mallee, the bark of whose roots was edible, and also (158) nala for its name in the Eucla region. Black (1926, 423) stated that *E. gracilis* was called kong mallee on Eyre Peninsula, and mentioned that a form of *E. oleosa* which had similar narrow leaves and very small fruits, was also so named in that locality (418). *E. gracilis* is widely distributed from New South Wales to Western Australia. Its fruits are said to be like those of *E. largiflorens*, for which Helms (1896, 325) obtained the name warralya in Hampton Plains. Though Mueller and Tate (1896) recorded the latter species from that locality, Black gave the range of *E. largiflorens* as River Murray and Eastern States. We suggest that the kong mallee of the Wirrung tribe may be *E. gracilis*.

Helms (1896, 322) gave gnalla (nalla) yera and gnalla (nalla) guya as names in the Fraser Range for the edible bark of a mallee while in its natural state, and gnalla yindalya for it after having been dried and pounded to dust, ready to be eaten. Yera = root, and kuyal or gual = green. Thus nalla or gnalla is the name of the particular mallee. The method of preparation of this material has been referred to by Helms (1896, 258-9, 304, 305-6). He also mentioned (325) *Eucalyptus caesia* (gungurru) as one species of mallee whose roots were so used in the Hampton Plains. This latter species was stated by Mueller and Tate (1896) to be close to *E. incrassata*.

#### UMBELLIFERAE

*Uldinia mercurialis*. The natives have no name for this plant, but it is included in our list since the generic name was based by J. M. Black (Flora, 3, 438) on "uldilnga gabi," the native name of the Ooldea Soak (gabi or kapi = water).

## ASCLEPIADACEAE

*Marsdenia australis*, poi-ya. Flower buds, stems and leaves eaten. The "silky pear" is kalgula. Basedow (1925) obtained the same name for the plant in the northern ranges. Helms (1896, 324) obtained the same term (boiya) as applied east of the Fraser Range to the plant and edible root of *Thysanotus Patersoni*, along with the names nurgu nurgu and malli malli, mentioning that the last name was applied to the plant and its tendrils. Bates (1918, 156) gave kalgula as the name of an edible fruit which she did not identify.

## BORAGINACEAE

*Halgania cyanea*, ngau-ngau. Helms (1896, 320) gave gnau-grau, apparently the same term, as being applied in the Blyth Range to *Eremophila latifolia*.

## VERBENACEAE

*Dicrastylis Beveridgei*, munni munni. Used in ceremonials. The same name was obtained for *Loranthus quandong*.

## SOLANACEAE

*Solanum coactiliferum*, e-toon, toon-ba.

*Solanum ellipticum*, e-toonba. Fruit esteemed. Bates (1819, 155) gives gujana. She also recorded kumba as the name of a *Solanum* and this name suggests kumberadda, the name of the native gooseberry in the Mann Ranges. Black (1917) obtained kumba as the name for *S. coactiliferum* at Murat Bay.

*Lycium australe*, djilka (= prickly).

*Nicotiana excelsior*. This plant does not grow in the Ooldea region, but its dried, prepared leaves are brought down from the Everard Ranges from time to time, depending largely on climatic conditions and their effect on the availability of water supplies along the route. The latter is referred to by Berndt (1941) and Johnston (1941). The material is termed pulandu, balandu, pulantu, and is chewed as a narcotic, after having been mixed with ashes (chiefly from *Acacia*) and often with rabbit or other mammalian fur. Ordinary tobacco is generally treated at Ooldea in the same way, being seldom smoked by men and women because of the few pipes available. The similarity of the plant to other species of *Nicotiana* was known at Ooldea. The term mingulba used in the Warburton and Musgrave Ranges was also given to us at Ooldea. Helms (1896, 320) gave the term pulanda for native tobacco, *Nicotiana suaveolens*, in the Blyth Range, but at that time the various Australian species of *Nicotiana* had not been satisfactorily differentiated, though he gave the name okiri for the same kind of plant in the Everard Ranges. We have discussed the various aboriginal narcotics in an earlier paper (Johnston and Cleland, 1933; 1934).

*Nicotiana Goodspeedii* Wheeler, to-wal to-wal. Not used. The term is the same as that obtained by us, tawalta walta for *Solanum ellipticum* in the Musgrave Range (1937, 211).

*Nicotiana rotundifolia* Wheeler, nungar-nunga. Not used. Perhaps this is the Wirrung name.

## MYOPORACEAE

*Myoporum platycarpum*, boolgar, boolgarba. The gum (boolgarba girrdi or kirrti) is used for attaching parts of spears, for connecting flints (lkandi) to spear-throwers, and for attaching hair or fur string to the pointing bone. The soft wood is used for making womerahs and shields and is also utilised in fire-making. Bates (1918, 154) gave djindidji as the Wirrung name for *Myoporum* sp.

*Eremophila* spp. Flowers are sucked to obtain nectar.

*Eremophila glabra*, mindyinga.

*Eremophila alternifolia*, mindyinga. Mr. Black informed us that walgala and gujaru are also applied to the plant.

*Eremophila maculata*, mindyinga (Mr. J. M. Black).

*Eremophila decipiens*, mindyinga.

*Eremophila gibsoni*, ta-lindera. Foliage used (amongst others) for making the tjali (wreath or pad) worn around the face in an inma (ceremony).

*Eremophila scoparia*, kwi-cru. Bates (1917) gave walgala as the Wurrung name, this being the same as that given above for *E. alternifolia*.

#### GOODENIACEAE

*Scaevola depauperata*, nahmbul nahnbul. Not used.

*Calotis erinacea*, ulunyu.

*Senecio Gregoryi*, tju-ter-uru. Same name is applied to a low-growing, yellow-flowered *Helichrysum*.

*Helichrysum apiculatum*, tju-ter-uru.

*Podosperma angustifolium*, tju-ter-uru. Flowers worn as hair ornaments by girls and young men.

#### FUNGI

Edible mushroom (*Psalliota*, probably n.sp.), tjanbi, tanbi. Mushroom (general term), tamunara, dhamunara, winji-na.

*Battarraea Stevenii*, tandi, tandu.

*Podaxon pistillaris*, kooma-kooma. Used for smearing face and forehead as a means for personal decoration.

Reddish bracket fungus, *Trametes cinnabarica*, muldu.

#### GENERAL TERMS

Tree, warrda; foliage, barraga barraga; plant food, ma, ma-i; leaf, nalbi, nalpi; stem or stick, boonoo; root, mi-na; bark, ligarra; ashes, purrgu; seeds, kalgu; camp made of any kind of bushes suitable for the framework or for the covering, ngura; vessel of bark or wood and used for digging or for carrying food and water, wi-ra; spear for close fighting, kadji; jabbing spear, winda; throwing spear, kula-da; boomerang, kali, kaili.

We have referred in this paper to the inma-tjali. Tjali, t(h)ali, or mang-ari is the pad of plant material, chiefly grass (but now at Ooldea composed mainly of old rags made into a ring-like pad), tied up with string made of fur of the wombat (wardu), and placed on the head for carrying loads. Inma means ceremony. The inma tjali is so named because the chief actors (dancers) wear a large conspicuous, wreath-like structure (tjali) which surrounds the face. It is composed of leaves and branchlets of any suitable convenient shrubs which can be formed into a thick ring. This wreath is kept in position by a transverse bar of plant material held in the mouth. The front portion of the wreath is decorated with white shavings obtained by scraping the sapwood of *E. incrassata* (in the cases observed by us), while the projecting decorated white sticks attached to the outer border of the wreath were obtained by scraping supple branchlets of the same tree. The ornamented projecting sticks bore, at intervals, series of curled shavings still attached at their base, just as Helms (1896, pl. xv, fig. 1; fig. 17) has indicated in his figures of the yindinga hair ornament for men in the Fraser Ranges, where it was made of young shoots of *Casuarina*. Berndt and Johnston reported that similar hair ornaments were worn by men during the inma which followed reburial ceremonies at Ooldea.

In addition to the various plants already mentioned by us as having been used in making the tjali, there was another called wallu-wallu, but we were unable to identify the shrub which had narrow linear lanceolate opposite leaves, rather greyish-green, and 2.5 cm. long. *Acacia brachystachya* supplied most of the material for the wreaths during our visit.

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# A SYSTEMATIC LIST OF THE HYDROIDA OF SOUTH AUSTRALIA WITH A SUMMARY OF THEIR DISTRIBUTION IN OTHER SEAS <sup>(1)</sup>

By M. BLACKBURN, M.Sc.  
(Communicated by B. C. Cotton)

## Summary

The list here presented includes all species recorded in the literature for definite South Australian localities, with one new record. It also includes forms recorded simply as from the Great Australian Bight, some of which may possibly have been taken west and not east of the Western Australian border, in addition to one (*Salacia sinuosa*, q.v.) which definitely was so recorded. "South Australia" for the present purpose, therefore, includes the whole of the Bight. Mr. J. A. Tubb has examined the collections of the late W. M. Bale in the Melbourne Museum, and Mr. R. E. Trebilcock has gone over his own collection, in order to ascertain whether there were any species that had been collected from South Australia but not recorded in the literature; none was found, but the author is nevertheless indebted to them for their efforts.

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The writer has briefly indicated in the publication the systems of classification followed. For each species the original reference and two or three additional ones are given, these latter having been selected so as to indicate, where possible, the whereabouts of good figures and recent summaries of the synonymy. The geographical distribution as known is also briefly stated for each form, and the type locality, as appearing from the literature, is given after the original reference for each. At the end of the list a summary of the facts of the geographical distribution is made.

Thanks are due to Dr. E. A. Briggs and Mr. R. E. Trebilcock for making available certain texts not otherwise procurable.

A page of line drawings of the commoner South Australian hydroids has been published in the South Australian Naturalist, 21, (2), 4, December 1941.

## CLASSIFICATION

The question of family and generic limits in the Hydroida has long been a vexed one, and several different schemes of classification have been put forward. The author therefore judges it desirable to indicate by which of the various systems he has been guided in allotting the species to genera and families.

**SERTULARIIDAE**—The conception of this family is as held by Broch (1918, pp. 6, 94-95), Stechow (1923, 153-158) and Spletstosser (1929, esp. 121), *i.e.*, as including the genera *Thyroscyphus* and *Parascyphus*, although Billard (1925, 135) specifically excludes them. As regards generic boundaries Broch (1918, 94-149), Billard (1925, 135-139) and Spletstosser (1929, esp. 122-130) have been generally followed, rather than Stechow (1923, 153-159). The genus *Sertularia* has, however, been regarded in the broad sense of Bale (1915, 258), *i.e.*, as including even the forms separated off by Broch (1918, 95) under the name *Odontotheca* (preocc., = *Amphisbetia*) as well as the genera *Tridentata* and *Nemella* of Stechow.

**SYNTHECIIDAE**—Bale (1915, 261-264) has been followed in referring *Stercotheca* (= *Levinsonia*, preocc.) to this family.

**PLUMULARIIDAE**—The classification of Bedot (1921a, 1921b, and 1923) has been followed, except that the genus *Antenella* has been dropped, and that the genus-name *Halicornaria* has been replaced by *Gymnangium* for the reasons given by Stechow (1923, 236).

<sup>(1)</sup> Contribution No. 21 from the Marine Biological Laboratory, C.S.I.R., Division of Fisheries, Cronulla, New South Wales.

CAMPANULARIIDAE—The author has generally followed Stechow (1923, 94-99), although his genus *Paracalix* has been dropped.

LAFOEIDAE—The species of the old "*Cryptolaria*" group have been re-allotted on the basis of the remarks of Totton (1931, 161-162, 166).

ATHECATA—The genus *Clathroozoon* is referred, following Stechow (1923, 59, 70), to the Bougainvilliidae; by the system of Broch (1916, 11, 43) it would also be placed here. The name "*Pennaria*" has been dropped in favour of *Halocordyle* for the reasons given by Stechow (1923, 47-48).

#### Order ATHECATA

##### Family BOUGAINVILLIIDAE

##### CLATHROOZON WILSONI Spencer 1891

*Clathroozoon wilsoni* Spencer 1891, 123, pls. xvii-xx (Port Phillip, Vict.). *Idem*, Bale, 1915, 244.

Great Australian Bight, South Australia, Victoria, New South Wales.

##### Family HALOCORDYLIDAE

##### HALOCORDYLE DISTICHA (Goldfuss 1820) var. AUSTRALIS (Bale 1884).

*Pennaria australis* Bale 1884, 45 (Port Jackson, N.S.W.).

*Halocordyle disticha* var. *australis*, Stechow, 1925, 194.

*Pennaria rosea* Lendenfeld, 1884, 594, pl. xxiv, fig. 40-42.

Western Australia, South Australia, New South Wales; also New Zealand, Japan, China, Indochina, East Indies, Mergui, Christmas Islands, India, Ceylon, East, West and South Africa. Other forms of the species also occur in the Mediterranean and West Indies regions.

#### Order THECATA

##### Family CAMPANULARIIDAE

##### CAMPANULARIA AUSTRALIS Stechow 1924

*Campanularia tinctoria* var. *e* Mulder and Trebilcock, 1914a, 13, pl. ii, fig. 12, pl. iii, fig. 9, 10 (Barwon Heads to Torquay, Vict.), and 1915, 56, pl. viii, fig. 2-2f (non *tinctoria* Hincks).

*Campanularia australis* Stechow 1924, 61, and 1925, 206, fig. D (*nom. nov.*).

Western Australia, South Australia, Victoria.

##### CAMPANULARIA PUMILA Bale 1914

*Campanularia pumila* Bale 1914a, 4, pl. i, fig. 6-8.

Great Australian Bight.

##### CAMPANULARIA PULCRATHECA Mulder and Trebilcock 1914

*Campanularia pulcrathecata* Mulder and Trebilcock 1914a, 11, pl. ii, fig. 1, 2 (Torquay, Vict.).

South Australia, Victoria.

##### SILICULARIA UNDULATA (Mulder and Trebilcock 1914)

*Eucopella undulata* Mulder and Trebilcock 1914a, 10, pl. ii, fig. 5-7 (Barwon Heads to Torquay, Vict.).

South Australia, Victoria, New South Wales.

##### ORTHOPYXIS MACROGONA (Lendenfeld 1884)

*Campanularia calyculata* var. *makrogona* Lendenfeld 1884, 922 (Port Phillip, Vict.).

*Orthopyxis macrogona*, Bale, 1914c, 77, pls. xi, xii, fig. 2.

South Australia, Victoria, New South Wales; also New Zealand.



## CLYTIA DELICATULA (Thornely 1900)

*Obelia delicatula* Thornely 1900, 453, pl. xlv, fig. 7 (New Britain).

*Clytia delicatula*, Stechow, 1913, 65, fig. xx, xxi. *Idem*, Blackburn, 1937b, 176, fig. 7.

South Australia, Victoria, Queensland; also New Britain, Philippines, Japan.

The following species is of uncertain position, owing to the absence of its gonosome in collected specimens, but seems fairly close to this genus:

## CLYTIA STOLONIFERA Blackburn 1938

*Clytia stolonifera* Blackburn 1938, 325, fig. 9, 10 (Banks Islands).

South Australia.

## OBELIA GENICULATA (Linne 1758)

*Sertularia geniculata* Linne 1758, 812.

*Obelia geniculata*, Bale, 1884, 59, pl. ii, fig. 2. *Idem*, Nutting, 1915, 73, pl. xviii, fig. 1-5.

Western Australia, South Australia, Victoria, New South Wales; also all seas, including the Arctic and Antarctic. (Type locality not specified.)

## OBELIA AUSTRALIS Lendenfeld 1884

*Obelia australis* Lendenfeld 1884, 604, 920, pl. xliii, fig. 19-22 (east coast, New Zealand). *Idem*, Blackburn, 1937b, 175, fig. 6.

South Australia, Victoria, Tasmania, New South Australia; also New Zealand, Ceylon, St. Paul Island.

## Family HALECIIDAE

## PHYLACTOTHECA ARMATA Stechow 1924

*Phylactotheca armata* Stechow 1924, 59, and 1925, 204, fig. C (Champion Bay, West. Aust.).

*Ophiodissa fragilis* Blackburn 1937a, 365, fig. 1.

Western Australia, South Australia, Victoria.

## HALECIUM MEDITERRANEUM Weismann 1883

*Halecium tenellum* var. *mediterranea* Weismann 1883, 160, pl. xi, fig. 5, 6 (Bay of Naples).

*Halecium mediterraneum* Stechow, 1919, 34.

*Halecium flexile* Allman 1888, 11, pl. v, fig. 2, 2a. *Idem*, Bale, 1915, 246.

South Australia, Victoria, Tasmania, New South Wales; also New Zealand, Pacific coast of North America (Nicaragua, British Columbia), Japan, Indochina, Ceylon, Marion Island, Mediterranean, West Africa, Patagonia, Antarctica.

## Family PLUMULARIIDAE

## KIRCHENPAUERIA MIRABILIS (Allman 1883)

*Diplocheilus mirabilis* Allman 1883, 49, pl. viii, fig. 4-7, (E. Moncoeur Island, Bass Strait).

*Kirchenpaueria mirabilis*, Bale, 1894, 109, pl. vi, fig. 4-7. *Idem*, Stechow, 1925, 241.

Western Australia, South Australia, Victoria, Tasmania (?), New South Wales; also New Zealand, South Africa.

## KIRCHENPAUERIA PRODUCTA (Bale 1882)

*Plumularia producta* Bale 1882, 39, pl. xv, fig. 3 (Queenscliff, Victoria), and 1884, 133, pl. x, fig. 4.

*Azygoplon productum*, Bale, 1888, 774, pl. xix, fig. 1-5.

*Kirchenpaueria producta*, Bale, 1914a, 59.

South Australia, Victoria, Bass Strait, New South Wales, Queensland; also Japan, California.

## KIRCHENPAUERIA BISEPTATA Blackburn 1938

*Kirchenpaueria biseptata* Blackburn 1938, 318, fig. 3 (Banks Islands).

South Australia.

## HALICORNOPSIS ELEGANS (Lamarck 1816)

*Plumularia elegans* Lamarck 1816, 129 (Indian Ocean).

*Halicornopsis avicularis* Bale, 1882, 14, pl. xiii, fig. 3, and 1884, 185, pl. x, fig. 1, 2, pl. xix, fig. 32.

*Halicornopsis elegans*, Briggs, 1914, 309.

Great Australian Bight, South Australia, Victoria, Tasmania, New South Wales; also Indian Ocean.

## THECOCAULUS OBCONICUS (Kirchenpauer 1876)

*Plumularia obconica* Kirchenpauer 1876, 46, fig. 5 on pl. i, iii, v (Gulf St. Vincent). *Idem*, Bale, 1884, 127, pl. xviii, fig. 3-4.

*Thecocaulus obconicus*, Bedot, 1921, b, 9.

South Australia. (This may be identical with *Schizotricha buski*, q.v.).

## THECOCAULUS OPPOSITUS (Mulder and Trebilcock 1911)

*Plumularia opposita* Mulder and Trebilcock 1911, 120, pl. ii, fig. 5 (Torquay, Vict.).

*Thecocaulus opposita*, Bedot, 1921b, 9. *Idem*, Blackburn, 1938, 316, fig. 2.

South Australia, Victoria.

## SCHIZOTRICHIA BUSKI (Bale, 1884)

*Plumularia buski* Bale 1884, 125, pl. x, fig. 3, pl. xix, fig. 34, 35 (Griffeth Point, Vict.), and 1915, 296.

*Schizotricha buski*, Bedot, 1921b, 12.

Great Australian Bight, South Australia, Victoria, Tasmania, Lord Howe Island; also Hawaii, Philippines, East Indies, Christmas Island, Ceylon.

## SCHIZOTRICHIA CAMPANULA (Busk 1852)

*Plumularia campanula* Busk 1852, 401 (Bass Strait). *Idem*, Bale, 1884, 124, pl. x, fig. 5, and 1915, 295.

*Schizotricha campanula*, Bedot, 1921b, 12.

South Australia, Victoria, Tasmania, New South Wales, Queensland, Torres Strait; also New Zealand, Japan, East Indies, Red Sea. (Both the typical and the *Antenella*-forms are found in Australia).

## SCHIZOTRICHIA SULCATA (Lamarck 1816)

*Plumularia sulcata* Lamarck 1816, 128 ("Southern Seas"). *Idem*, Briggs, 1914, 306, pl. xi, fig. 1.

*Plumularia aglaophenoides* Bale, 1884, 126, pl. x, fig. 6.

*Schizotricha sulcata*, Bedot, 1921b, 13.

South Australia, Bass Strait, Tasmania, New South Wales; also Philippines.

## SCHIZOTRICHIA SECUNDARIA (Gmelin 1788-1793)

*Sertularia secundaria* Gmelin 1788-1793, 3,854 (Mediterranean).

*Antenella secundaria*, Bedot, 1914, 82, pl. v, fig. 1, 7, 8.

*Plumularia liechtensternei* Marktanner 1890, 257, pl. vi, fig. 2, 2a.

*Schizotricha liechtensternei*, Bedot, 1921 b, 13.

South Australia, Victoria, Bass Strait (?), Torres Strait; also Tonga, Japan, Indochina, East Indies, Ceylon, Andaman and Mergui Islands, Chagos Archipelago, Madagascar, East Africa, South Africa, St. Paul Island, Mediterranean, North-East Atlantic from England to Cape Verde Islands, West Indies. (Only the *Antenella*-form has so far been found in Australia).

## PLUMULARIA ASYMMETRICA Bale 1914

*Plumularia asymmetrica* Bale 1914a, 29, pl. iv, fig. 2, 3.

Great Australian Bight.

## PLUMULARIA AUSTRALIS Kirchenpauer 1876

*Plumularia obliqua* var. *australis* Kirchenpauer 1876, 49, pl. vi, fig. x (Port Phillip, Vict.).

*Plumularia australis*, Bale, 1884, 143, pl. xii, fig. 7, 8, pl. xix, fig. 43, 44.

South Australia, Victoria.

## PLUMULARIA COMPRESSA Bale 1882

*Plumularia compressa* Bale 1882, 43, pl. xv, fig. 5 (Robe, South Australia), and 1884, 142, pl. xii, fig. 9, 10, pl. xix, fig. 39, 40.

*Monothecella compressa*, Stechow, 1925, 243.

Western Australia, South Australia, Victoria, New South Wales.

## PLUMULARIA PULCHELLA Bale 1882

*Plumularia pulchella* Bale 1882, 42, pl. xv, fig. 6 (Queenscliff, Victoria), and 1884, 140, pl. xii, fig. 6, pl. xix, fig. 37. *Idem*, Totton, 1931, 221, fig. lviii.

*Plumularia flexuosa* Bale 1894, 115, pl. v, fig. 6-10.

Western Australia, South Australia, Victoria, New South Wales; also New Zealand, South Africa.

## PLUMULARIA OBLIQUA (Johnston 1847)

*Laomedea obliqua* Johnston 1847, 106, pl. xxviii, fig. 1 (Brighton, England).

*Plumularia obliqua*, Bale, 1884, 138, pl. xii, fig. 1-3.

*Monotheca obliqua*, Stechow, 1919, 113.

South Australia, Victoria, Tasmania; also North-East Atlantic (England, France), Mediterranean, Japan.

## PLUMULARIA OBESA Blackburn 1938

*Plumularia obesa* Blackburn 1938, 315, fig. 1 (Banks Island).

South Australia.

## PLUMULARIA PROCUMBENS Spencer 1891

*Plumularia procumbens* Spencer 1891, 130, pls. xxi-xxiii (Port Phillip, Victoria).

Great Australian Bight, South Australia, Victoria, Tasmania.

## PLUMULARIA ANGUSTA Stechow 1923

*Plumularia setaceoides* vars. *a*, *b*, *d* Mulder and Trebilcock, 1911, 117-118, pl. iii, fig. 3, 6, pl. ii, fig. 9. (Point Lonsdale, Corio Bay, Torquay, Victoria), non *setaceoides* Bale).

*Plumularia angusta* Stechow 1923, 226 (*nom. nov.*).

South Australia, Victoria.

## GYMNANGIUM BIROSTRATUM (Bale 1914)

*Halicornaria birostrata* Bale 1914a, 49, pl. iv., fig. 5, pl. vii, fig. 6.  
*Gymnangium birostratum*, Stechow, 1923, 236.

Great Australian Bight.

## GYMNANGIUM LONGIROSTRE (Kirchenpauer 1872)

*Aglaophenia longirostris* Kirchenpauer 1872, 42, pl. i, fig. 19, pl. v, fig. 20  
 (Wilson's Promontory, Victoria).  
*Halicornaria longirostris*, Bale, 1884, 181, pl. xiii, fig. 7, pl. xvi, fig. 3, pl. xix,  
 fig. 30. *Idem*, Briggs, 1914, 311.  
*Gymnangium longirostre*, Stechow, 1923, 236.

South Australia, Victoria, Tasmania, New South Wales.

## GYMNANGIUM TUBULIFERUM (Bale 1914)

*Halicornaria tubulifera* Bale 1914b, 187, pl. xxxvi, fig. 3.  
*Gymnangium tubuliferum*, Stechow, 1923, 237.

Great Australian Bight.

## GYMNANGIUM URCEOLIFERUM (Lamarck 1816)

*Plumularia urceolifera* Lamarck 1816, 125 (Indian Ocean).  
*Halicornaria urceolifera*, Bale, 1914a, 51, pl. v, fig. 4, pl. vii, fig. 5, and 1914b,  
 183, pl. xxxvii, fig. 5, 6.  
*Gymnangium urceoliferum*, Stechow, 1923, 237.

Great Australian Bight (typical form and var. *scandens* Bale); and Indian Ocean.

## GYMNANGIUM VEGAE (Jaderholm 1903)

*Halicornaria vegae* Jaderholm 1903, 301, pl. xv, fig. 1-4 (South Japan). *Idem*,  
 Bale, 1914b, 185, pl. xxxvi, fig. 4, 5.  
*Gymnangium vegae*, Stechow, 1923, 237.

Great Australian Bight; also Japan.

The two following species can be only tentatively assigned to the genus, as the gonosomes are not yet known:

## GYMNANGIUM ILICISTOMUM (Bale 1882)

*Aglaophenia ilicistoma* Bale 1882, 33, pl. xiv, fig. 4 (Queenscliff, Victoria, and Robe, South Australia).  
*Halicornaria ilicistoma*, Bale, 1884, 184, pl. xiv, fig. 2, pl. xvi, fig. 9.  
*Gymnangium ilicistomum*, Stechow, 1923, 237.

South Australia, Victoria.

## GYMNANGIUM SUPERBUM (Bale 1882)

*Aglaophenia superba* Bale 1882, 31, pl. xiii, fig. 4 (Griffeth Point, Victoria).  
*Halicornaria superba*, Bale, 1884, 175, pl. xii, fig. 1, pl. xvi, fig. 4, and 1915, 324.  
*Gymnangium superbum*, Stechow, 1923, 237.

Western Australia, South Australia, Victoria, Tasmania.

## THECOCARPUS CALYCIFERUS (Bale 1914)

*Aglaophenia calycifera* Bale 1914b, 178, pl. xxxvii, fig. 3, 4 (Great Australian Bight).  
*Thecocarplus calyciferus*, Bedot, 1921a, 332.

Great Australian Bight; also ? Philippines.

## THECOCARPUS MEGALOCARPUS (Bale 1914)

*Aglaophenia megalocarpa* Bale 1914a, 45, pl. iv, fig. 1, pl. vi, fig. 5.  
*Thecocarpus megalocarpa*, Bedot, 1921a, 333.

Great Australian Bight.

## THECOCARPUS TENUISSIMUS (Bale 1914)

*Aglaophenia tenuissima* Bale 1914b, 179, pl. xxxvii, fig. 1, 2 (Great Australian Bight).

*Thecocarpus tenuissima*, Bedot, 1921a, 334.

Great Australian Bight, Bass Strait, Tasmania.

## AGLAOPHENIA BILLARDI Bale 1914

*Aglaophenia billardi* Bale 1914a, 33, pl. iii, fig. 3, pl. vi, fig. 3.

Great Australian Bight.

## AGLAOPHENIA DANNEVIGI Bale 1914

*Aglaophenia dannevigii* Bale 1914a, 41, pl. iii, fig. 4, pl. vi, fig. 4.

Great Australian Bight.

## AGLAOPHENIA DIVARICATA (Busk 1852)

*Plumularia divaricata* Busk 1851, 398 (Bass Strait).

*Aglaophenia divaricata*, Bale, 1884, 162, pl. xv, fig. 7, 8, pl. xvii, fig. 6, 7, and 1915, 309-315.

South Australia (typical form and var. *cystifera* Bale), Victoria, Tasmania, New South Wales, Lord Howe Island; also Philippines.

## AGLAOPHENIA PLUMOSA Bale 1882

*Aglaophenia plumosa* Bale 1882, 37, pl. xiv, fig. 6 (Queenscliff, Victoria, and Aldinga South, South Australia), and 1884, 153, pl. xiv, fig. 5, pl. xvii, fig. 12. *Idem*, Stechow, 1925, 260.

Western Australia, South Australia, Victoria, New South Wales; also New Zealand, South Africa.

## AGLAOPHENIA RAMULOSA Kirchenpauer 1872

*Aglaophenia ramulosa* Kirchenpauer 1872, 41, pl. i, fig. 18 (Port Lincoln, South Australia). *Idem*, Bale, 1884, 170, pl. xviii, fig. 11. *Idem*, Stechow, 1932, 89.

*Aglaophenia acanthocarpa* Allman, 1876, 274, pl. xxi, fig. 1-4.

South Australia; also New Zealand, Kermadec Island, ? West Indies.

The following species can only be tentatively assigned to the genus, as the gonosome is not yet known:

## AGLAOPHENIA CARINIFERA Bale 1914

*Aglaophenia carinifera* Bale 1914b, 181, pl. xxxviii, fig. 1, 2.

Great Australian Bight.

## AGLAOPHENIA WHITELEGGEI Bale 1888

*Aglaophenia whiteleggei* Bale 1888, 794, pl. xxi, fig. 8. *Idem*, Stechow, 1913, 99, fig. 68-70.

South Australia (Encounter Bay, new record, coll. F. K. Godfrey), Victoria, New South Wales; also Japan. Type locality not specified.

## Family LAFOEIDAE

## HEBELLA CALCARATA (L. Agassiz 1862)

*Laodicea calcarata* L. Agassiz 1862, 350 (Buzzard's Bay, Massachusetts).

*Hebella calcarata*, Bale, 1915, 251.

*Lafoea scandens*, Bale, 1888, 758, pl. xiii, fig. 16-19.

South Australia, Victoria, Tasmania, New South Wales, Lord Howe Island; also New Zealand, Pacific Coasts of Mexico and Panama, Japan, Philippines, East Indies, Indochina, Maldive Island, Ceylon, East, South and West Africa, Mediterranean, West Indies, Atlantic Coast of United States, Greenland.

## ACRYPTOLARIA ANGULATA (Bale 1914)

*Cryptolaria angulata* Bale 1914b, 166, pl. xxxv, fig. 1.

Great Australian Bight.

## ACRYPTOLARIA ARBORIFORMIS (Ritchie 1911)

*Cryptolaria arboriformis* Ritchie 1911, 824, pl. lxxxiv, fig. 1, pl. lxxxvii, fig. 7 (off Coogee, New South Wales). *Idem*, Bale, 1915, 248.

South Australia, Tasmania, New South Wales.

## CRYPTOLARIA EXSERTA Busk 1858

*Cryptolaria exserta* Busk 1858, 130, pl. xix, fig. 3-3b (Madeira).

*Perisiphonia exserta*, Bale, 1915, 247.

*Perisiphonia filicula* Allman, 1888, 44, pl. xxii, fig. 1-4.

Great Australian Bight, Tasmania, New South Wales; also Japan, Madeira, Azores, ?Atlantic coast of France.

## Family LINEOLARIIDAE

## LINEOLARIA FLEXUOSA Bale 1884

*Lineolaria flexuosa* Bale 1884, 62, pl. i, fig. 7-9 (Williamstown, Victoria). *Idem*, Blackburn, 1938, 321.

South Australia, Victoria; also New Zealand.

## LINEOLARIA INARMATA Blackburn 1938

*Lineolaria inarmata* Blackburn 1938, 321, fig. 4-8 (Banks Islands).

South Australia.

## Family SYNTHECIIDAE

## SYNTHECIUM ELEGANS Allman 1872

*Synthecium elegans* Allman 1872, 229, fig. (New Zealand). *Idem*, Billard 1925, 129, fig. 5.

*Synthecium subventricosum* Bale, 1914a, 5, pl. i, fig. 3-5.

Great Australian Bight; also New Zealand, Kermadec Islands, East Indies, South and East Africa.

## STEREOTHECA ELONGATA (Lamouroux 1816)

*Sertularia elongata* Lamouroux 1816, 189, pl. v, fig. 3-3c ("Australasia"). *Idem*, Bale, 1884, 75, pl. vi, fig. 7, 8, pl. xix, fig. 7.

*Stereotheca elongata*, Stechow, 1925, 231.

Western Australia, South Australia, Victoria, Tasmania, New South Wales; also New Zealand, South Africa, and the North Sea.

## STEREOTHECA ACANTHOSTOMA (Bale 1882)

*Sertularia acanthostoma* Bale 1882, 23, pl. xii, fig. 4 (Robe, South Australia), and 1884, 85, pl. iv, fig. 7, 8.

*Stereotheca acanthostoma*, Stechow, 1919, 103.

South Australia, Victoria.

## Family SERTULARIIDAE

## THYROSCYPHUS MARGINATUS (Bale 1884)

*Campanularia marginata* Bale 1884, 54, pl. i, fig. 2 (Queenscliff, Portland Victoria).

*Thyroscyphus marginatus*, Stechow, 1925, 217.

Western Australia, South Australia, Victoria, New South Wales; also Philippines.

## PARASCYPHUS SIMPLEX (Lamouroux 1816)

*Laomedea simplex* Lamouroux 1816, 206 ("Australasia").

*Parascyphus simplex*, Stechow, 1925, 224.

*Campanularia tridentata* Bale, 1894, 98, pl. iii, fig. 3.

Western Australia, South Australia, Victoria, Tasmania; also New Zealand, Scotland and Gough Island, South Atlantic.

## DIPHASIA ATTENUATA (Hincks 1866)

*Sertularia attenuata* Hincks 1866, 298 (England, various localities).

*Diphasia attenuata* Hincks 1868, 247, pl. xlix, fig. 1. *Idem*, Bale, 1884, 100, pl. ix, fig. 2.

South Australia; also North-East Atlantic (North-West coast of Africa, English Channel, North Sea), and Arctic Ocean.

## DIPHASIA SUBCARINATA (Busk 1852)

*Sertularia subcarinata* Busk 1852, 390 (Bass Strait).

*Diphasia subcarinata*, Bale, 1884, 103, pl. iv, fig. 1, pl. xix, fig. 18, and 1914a, 7.

Great Australian Bight, South Australia, Victoria, Tasmania, New South Wales, Torres Strait.

## HYPOPYXIS LABROSA Allman 1888

*Hypopyxis labrosa* Allman 1888, 74, pl. xxxv, fig. 1, 1a (off Twofold Bay, New South Wales).

*Hypopyxis distans* Bale, 1914b, 167, pl. xxxv, fig. 2-5.

Great Australian Bight, New South Wales.

## DYNAMENA CRISIODES Lamouroux 1824

*Dynamena crisiodes* Lamouroux 1824, 613, pl. xc, fig. 11, 12 (Moluccas). *Idem*, Billard, 1925, 181, pl. vii, fig. 21, text fig. 36, 37.

? Western Australia, South Australia, New South Wales, Lord Howe Island, Queensland; also the Fiji, Gilbert, Ellice and Marshall Islands, Japan, China, Indochina, Philippines, East Indies, Christmas Island, Maldive-Laccadive Island, India, Ceylon, East Africa, Seychelles, Chagos Archipelago, Madagascar, South Africa, tropical West Africa, tropical America, both Atlantic and Pacific, and ? Iceland.

## DYNAMENA QUADRIDENTATA (Ellis and Solander 1786)

*Sertularia quadridentata* Ellis and Solander 1786, 57, pl. v, fig. G (near Ascension).

*Pasythea quadridentata*, Bale, 1884, 112, pl. vii, fig. 3. *Idem*, Nutting, 1904, 75, pl. xiii, fig. 4-7.

*Dynamena quadridentata*, Billard, 1925, 194.

Western Australia, South Australia, New South Wales, Lord Howe Island, Queensland; also New Zealand, Loyalty Island, Hawaii, Japan, China, Philippines, East Indies, India, Ceylon, South and South-East Africa, Ascension Island, Azores, Atlantic Ocean, Sargasso Sea, Carolina, West Indies, Massachusetts, tropical Pacific America.

## DYNAMENA CORNICINA McCrady 1859

*Dynamena cornicina* McCrady 1859, 204 (Charleston, South Carolina). *Idem*, Billard, 1925, 188, pl. vii, fig. 23, text-fig. 40.

*Sertularia cornicina*, Nutting, 58, pl. iv, fig. 1-5.

South Australia, New South Wales; also Japan, Indochina, East Indies, Andaman Islands, Ceylon, East Africa, Mediterranean, Madeira, North-West Africa, Nova Scotia, Massachusetts, Carolina, Yucatan, West Indies, Brazil, California and Pacific coast of Mexico.

## SERTULARIA OPERCULATA Linne 1758

*Sertularia operculata* Linne 1758, 808. *Idem*, Bale, 1884, 67, pl. vi, fig. 1, pl. xix, fig. 3. *Idem*, Nutting, 1904, 54, pl. ii, fig. 3-5.

South Australia, Victoria, Tasmania, New South Wales; also New Zealand, Auckland Island, Java, Indian Ocean, St. Paul Island, Kerguelen, South Africa, Azores, North-West Africa, Atlantic coasts of Europe, Mediterranean, Arctic, Patagonia, Magellan Strait, Falkland Islands. (Type locality not specified.)

## SERTULARIA BISPINOSA (Gray 1843)

*Dynamena bispinosa* Gray 1843, 294 (New Zealand).

*Sertularia bispinosa*, Bale, 1884, 68, pl. vi, fig. 2, pl. xix, fig. 4, 5. *Idem*, Nutting, 1940, 56, pl. ii, fig. 8-11.

South Australia, Victoria, ?Bass Strait, Lord Howe Island; also New Zealand, Indian Ocean, east coast of South America.

## SERTULARIA MAPLESTONEI Bale 1884

*Sertularia maplestonei* Bale 1884, 70, pl. vi, fig. 4, pl. xix, fig. 2 (Portland, Victoria), and 1914a, 16.

*Sertularia bidens* Bale, 1884, 70, pl. vi, fig. 6, pl. xix, fig. 1.

*Sertularia pulchella* Thompson, 1879, 108, pl. xviii, fig. 3, 3a.

South Australia, Victoria, Tasmania, New South Wales; also South Africa, Madagascar.

## SERTULARIA UNGUICULATA Busk 1852

*Sertularia unguiculata* Busk 1852, 394 (Banks Strait, Tasmania). *Idem*, Bale, 1884, 76, pl. vi, fig. 9-12, pl. xix, fig. 8. *Idem*, Totton, 1931, 203, fig. 48a.

Western Australia, South Australia, Victoria, Tasmania, New South Wales; and New Zealand.



## SERTULARIA RECTA Bale 1882

*Sertularia recta* Bale 1882, 23, pl. xii, fig. 5 (Brighton, South Australia), and 1884, 79, pl. v, fig. 1.  
South Australia, Victoria.

## SERTULARIA TENUIS Bale 1884

*Sertularia tenuis* Bale 1884, 82, pl. v, fig. 4, 5, pl. xix, fig. 16 (Williamstown, Victoria), and 1913, 129.

*Sertularia divergens* Busk (*non* Lamouroux), 1852, 392. *Idem*, Bale, 1884, 81, pl. v, fig. 3, pl. xix, fig. 16.

South Australia, Victoria, Tasmania; also New Zealand, Tahiti, Philippines, Maldive-Laccadive Islands, ?Ceylon, East Africa.

## SERTULARIA MINIMA Thompson 1879

*Sertularia minima* Thompson 1879, 104, pl. xvii, fig. 3-3b (Gulf St. Vincent, South Australia). *Idem*, Bale, 1884, 89, pl. iv, fig. 9, 10, pl. xix, fig. 12, 13. *Amphisbetia minima*, Stechow, 1925, 230, fig. K.

Western Australia, South Australia, Victoria, New South Wales, Lord Howe Island; also New Zealand, Kermadec Island, Suez, South Africa, Falkland Islands, Chile.

## SERTULARIA MUELLERI Bale 1913

*Sertularia muelleri* Bale 1913, 133, pl. xii, fig. 1-5 (Encounter Bay, South Australia).

South Australia, Victoria.

## SERTULARIA GEMINATA Bale 1884

*Sertularia geminata* Bale 1884, 78, pl. v, fig. 6, 7, pl. xix, fig. 15 (Queenscliff, Portland, Victoria), and 1915, 273.

South Australia, Victoria, Bass Strait.

## SERTULARIA MARGINATA (Kirchenpauer 1864)

*Dynamena marginata* Kirchenpauer 1864, 13, fig. 8-8c (Pacific Ocean).

*Sertularia marginata*, Bale, 1913, 133, pl. xii, fig. 1-5. *Idem*, Totton, 1931, 204, fig. 48b.

South Australia, Victoria; also New Zealand, Mediterranean, East Africa, West Africa, Cape Verde Islands, ?Azores, West Indies, Brazil ?Carolina.

## SERTULARIA BRUNNEA (Stechow 1923)

*Sertularia* sp., Thompson, 1879, 106, pl. xviii, fig. 1-1b (Gulf St. Vincent, South Australia).

*Tridentata brunnea* Stechow 1923, 206 (*nom. nov.*).

South Australia. This species may be identical with *S. unguiculata* (q.v.).

## SERTULARIA MINUSCULA Bale 1919

*Sertularia minima* var. *tubatheca* Mulder and Trebilcock, 1914b, 40, pl. iv, fig. 1-1d (Queenscliff, Victoria).

*Sertularia minuscula* Bale 1919, 340.

South Australia, Victoria, Tasmania.

## SERTULARELLA INDIVISA Bale 1882

*Sertularella indivisa* Bale 1882, 24, pl. xii, fig. 7 (Williamstown, St. Kilda, Victoria), and 1884, 105, pl. iii, fig. 5, pl. xix, fig. 27, and 1915, 285.

South Australia, Victoria, Tasmania, New South Wales, Lord Howe Island; also ?Tahiti, Chatham Islands, Japan, Cuba.

## SERTULARELLA PYGMAEA Bale 1882

*Sertularella pygmaea* Bale 1882, 25, pl. xii, fig. 9 (Queenscliff, Griffith Point, Victoria), and 1884, 108, pl. iii, fig. 8, pl. xix, fig. 19.

South Australia, Victoria, New South Wales; and New Zealand.

## SERTULARELLA DIVARICATA (Busk 1852)

*Sertularia divaricata* Busk 1852, 388 (Bass Strait).

*Sertularella divaricata*, Bale, 1884, 110, pl. iii, fig. 9, pl. xix, fig. 20, and 1914a, 20, pl. ii, fig. 1-9.

Great Australian Bight, South Australia, Victoria, Tasmania, New South Wales, Queensland; also Patagonia, Strait of Magellan, Tierra del Fuego, Chile, Antarctica.

## SERTULARELLA NEGLECTA Thompson 1879

*Sertularella neglecta* Thompson 1879, 100, pl. xv, fig. 1 ("Australia, probably Bass Strait"). *Idem*, Bale, 1884, 110, pl. iii, fig. 3, pl. xix, fig. 22, 23, and 1915, 287.

South Australia, Victoria, ?Bass Strait.

## SERTULARELLA LATA (Bale 1882)

*Thuiaria lata* Bale 1882, 26, pl. xiii, fig. 2 (Griffith Point, Victoria), and 1884, 120, pl. vii, fig. 4.

*Sertularella lata*, Bale, 1915, 287.

Great Australian Bight, Victoria, New South Wales, Torres Strait.

## SERTULARELLA ROBUSTA Coughtrey 1875

*Sertularella robusta* Coughtrey 1875, 300 (Otago, New Zealand). *Idem*, Trebilcock, 1928, 16, pl. vi, fig. 3-3c. *Idem*, Blackburn, 1937b, 171, fig. 1.

South Australia, Victoria, ?Tasmania, ?New South Wales; also New Zealand, East Indies, Tierra del Fuego.

The following species is not known from South Australia proper, but is recorded from the Great Australian Bight, in longitude 127° east, which is somewhat west of the South Australian-Western Australian border. It seems reasonable to include it here, however, the more so as it is recorded also from Tasmania and (with doubt) from Victoria:

## SALACIA SINUOSA (Bale 1888)

*Thuiaria sinuosa* Bale 1888, 772, pl. xviii, fig. 9, 10 (Port Molle, Queensland), and 1915, 279.

*Salacia sinuosa*, Billard, 1915, 204, pl. viii, fig. 20, text-fig. 48.

Great Australian Bight, ?Victoria, Tasmania, New South Wales, Lord Howe Island, Queensland; also East Indies.

The list just given includes, as has already been pointed out, all species definitely known to occur in the waters of South Australia, including all the Bight. However, there are a few other forms which have been recorded both from Victoria or Bass Strait, and from south-western Australia (*i.e.*, Western Australia, south of the Tropic), and which could therefore be regarded as likely to occur, and to some time be discovered, in South Australia. For the sake of the student collector this list is briefly presented below, with one good reference to each species:

#### Order ATHECATA

##### Family HALOCORDYLIDAE

*Halocordyle wilsoni* (Bale 1913). (See Blackburn, 1937b, 176, fig. 8, 9, as *Pennaria wilsoni*).

##### Family CAMPANULARIIDAE

*Campanularia ambiplica* Mulder and Trebilcock 1914. (See Stechow, 1925, 209, fig. E, as *Paracalix ambiplica*).

##### Family PLUMULARIIDAE

*"Antenella" dubia* (Mulder and Trebilcock 1911). (See Mulder and Trebilcock, 1911, 115, pl. ii, fig. 6, as *Plumularia campanulaformis* var. *dubia*.)

*Plumularia crateriformis* Mulder and Trebilcock 1911. (See Mulder and Trebilcock, 1911, 118, pl. iii, fig. 8, 8, as *P. setaceoides* var. *crateriformis*.)

*Plumularia setaceoides* Bale 1882. (See Bale, 1884, 136, pl. xi, fig. 8, pl. xix, fig. 36.)

*Plumularia spinulosa* Bale 1882. (See Bale, 1884, 139, pl. xii, fig. 11, 12.)

##### Family SERTULARIIDAE

*Sertularia ligulata* Thornely 1904. (See Stechow, 1925, 232, fig. L, as *Tridentata turbinata*.)

*Idiella pristis* (Lamouroux 1816). (See Allman, 1888, p. 85, pl. xxxix, fig. 1-10, as *Idia pristis*.)

#### DISTRIBUTION OF SOUTH AUSTRALIAN HYDROIDS IN OTHER WATERS

The percentages of South Australian Hydroids occurring in other waters, both in Australia and beyond, indicate the relative affinities of other seas to those of South Australia in this respect. In the following brief analysis on these lines doubtful records are considered.

Of the 84 species of Hydroida definitely listed for South Australia (including the Bight) there are:

16 (19%) peculiar to South Australia; 15 (18%) which range into Western Australia, excluding the Bight; 54 (63%) which range into Victoria<sup>(2)</sup>; 28.5 (34%) which range into Tasmania<sup>(3)</sup>; 37 (44%) which range into New South Wales<sup>(4)</sup>; 9 (11%) which range into Queensland, including Torres Strait; 25 (30%) which range into New Zealand, including Kermadec and Chatham

<sup>(2)</sup> Actually the figure is 53 (63%), but if Bass Strait is included it becomes 55 (65%). We take the mean of these two.

<sup>(3)</sup> Actually the figure is 27 (32%), but if Bass Strait is included it becomes 30 (36%). We take the mean of these two.

<sup>(4)</sup> Actually the figure is 36 (43%), but if Lord Howe Island is included it becomes 37 (45%). We take the mean of these two.

Islands; 16 (19%) which range into Japan; 7 (8%) which range into Pacific coasts of North America; 4 (5%) which range into Pacific coasts of South and Central America, excluding the Patagonian region; 20 (24%) with range into Indo-Malaya (Philippines, East Indies, India, etc.); 6 (7%) which range into Oceania (New Britain, Hawaii, Tahiti, etc.); 12 (14%) which range into East Africa, including Red Sea, Madagascar, etc.; 14 (17%) which range into South Africa; 12 (14%) which range into West Africa, including Ascension, Azores, etc.; 9 (11%) which range into the Mediterranean; 7 (8%) which range into Atlantic coasts of Europe; 4 (5%) which range into Atlantic coasts of Canada-U.S.A. to the Gulf of Mexico; 9 (11%) which range into the Brazil-Caribbean region; 6 (7%) which range into the Patagonian region; 4 (5%) which range into the Arctic Ocean; 6 (7%) which range into the Subantarctic Islands (St. Paul, Barion, Gough, Kerguelen, Macquarie, Auckland Islands); 3 (4%) which range into Antarctica.

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# **THE LIFE HISTORY OF THE TREMATODE, PARYPHOSTCIMUM TENUICOLLIS (S. J. JOHNSTON)**

By T. HARVEY JOHNSTON and L. MADELINE ANGEL, University of Adelaide

## **Summary**

During routine examinations of the fluke parasitism of pond snails in the Tailem Bend swamps carried out since April 1937, we have found a 27-spined echinostome cercaria to be one of the most common parasites of *Americanna* spp. Altogether it has occurred in 655 of a total of 12,482 of the snails examined (5.2%). The greatest numbers of snails found infected with the cercariae were 88 of 676 (in April 1939) and 194 of 1,687 (December 1941). We have obtained the cercaria from October to May, inclusive. *Amerianna pyramidata* and *A. pectorosa* were the most common hosts, but *A. tenuistriata* was also found infected.

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TREMATODE, PARYPHOSTOMUM TENUICOLLIS (S. J. Johnston)**

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[Read 13 August 1942]

During routine examinations of the fluke parasitism of pond snails in the Tailem Bend swamps carried out since April 1937, we have found a 27-spined echinostome cercaria to be one of the most common parasites of *Amerianna* spp. Altogether it has occurred in 655 of a total of 12,482 of the snails examined (5.2%). The greatest numbers of snails found infected with the cercariae were 88 of 676 (in April 1939) and 194 of 1,687 (December 1941). We have obtained the cercaria from October to May, inclusive. *Amerianna pyramidata* and *A. pectorosa* were the most common hosts, but *A. tenuistriata* was also found infected.

In November 1939, two of 187 *Amerianna* spp. collected from the John Warren Reservoir, South Australia, were parasitised with the same cercaria which we also obtained from two of 41 of these snails from the River Finniss in March 1941.

Because of the number and arrangement of collar spines, we had for some time thought this cercaria to be the larva of *Paryphostomum tenuicollis* (S. J. Johnston), which we have found to be a very common parasite of cormorants, *Phalacrocorax* spp., from the River Murray area.

We have several times attempted to infect snails (*Amerianna* spp., *Limnaca lessoni* and *Planorbis isingi*) by placing them in small tanks or dishes containing eggs of *Paryphostomum tenuicollis*. The snails were kept in the containers for six to eight weeks (to allow for hatching of miracidia), and were then transferred to aquaria. The snails were tested weekly while they were alive (by isolation in small tubes of water), and were dissected when they died. Only one of the snails (an *Amerianna pectorosa*) produced cercariae, which were of the familiar 27-spined form. The snail had been placed in contact with eggs on 15 December 1941, and further eggs were added to the tank on 3 February 1942. On 25 March the snail commenced to give off cercariae. The other eleven *Amerianna* in the tank had died within four weeks of the original infection; six *Amerianna* added at the time of the second infection were too disintegrated when found dead to show whether any rediae had been present.

This small percentage of positive results with experimental infections is not uncommon in our experience. We consider that the main reason is that the fluke eggs are often not viable, from one cause or another.

Since February 1940 a 27-spined cercaria has been found in 90 of 1,299 *Limnaca lessoni* from Tailem Bend. The cercariae from this host tend to be slightly smaller than *Cercaria Paryphostomi-tenuicollis* from *Amerianna* spp., though morphologically we are not able to distinguish them. These cercariae encyst in the same kind of fish and tadpoles, and the cysts are similar to those of *Paryphostomum tenuicollis*, though they also are a trifle smaller. The size and arrangement of the corner and shoulder spines of the collar of the metacercariae derived from the two snail hosts are the same, and the only feature by which the collars may have been distinguished, i.e., the relative sizes of the spines in the two dorsal rows, did not allow of accurate determination.

In the absence of experimental evidence proving the cercaria from *Limnaca* to be the larva of *P. tenuicollis*, we have used the cercaria from *Amerianna* spp. as our type. We have not previously recorded any single species of cercaria occurring in two such different snail hosts as *Amerianna* and *Limnaca*.



## ADULT

The adult was described originally as *Echinochasmus tenuicollis* by the late Professor S. J. Johnston (1916) from *Phalacrocorax melanoleucus* from New South Wales. We have collected it, sometimes in great abundance, from *P. carbo* (Tailent Bend; Hope Valley Reservoir), *P. melanoleucus*, *P. fuscescens* and *P. sulcirostris* (syn. *P. ater*) (all from Tailent Bend).

The following are measurements of the collar spines of one specimen (in glycerine): corner spines breadth, 25 to 27  $\mu$ ; length of ventral inner spines, 112  $\mu$ ; ventral outer, 105  $\mu$ ; upper inner, 118  $\mu$ ; upper outer, 136  $\mu$ ; next spine (which is in series with the second row of dorsal spines), 92 to 97  $\mu$  by 17.5  $\mu$ ; shoulder spines, 107  $\mu$  by 17.5  $\mu$ ; anterior dorsal series, 102  $\mu$  by 17.5  $\mu$ ; second dorsal series, 92 to 95  $\mu$  by 17.5  $\mu$ .

## THE EGG

Size, about 70-84  $\mu$  long by 58-63  $\mu$ . The miracidium has not been observed.

## REDIA

Rediae when dissected from the snails seemed to fall into two distinct size groups. The larger of these had a range (for ten specimens) of 1.1-1.5 mm. in length and 120-170  $\mu$  in breadth; while for the smaller group the range in length was 300-585  $\mu$  (average 415  $\mu$ ), and in breadth 58-84  $\mu$  (average 67  $\mu$ ). It seems probable that the smaller group was composed of daughter rediae, since there were very few rediae intermediate in size between the two groups; but none of these "daughter rediae" was seen within the "mother redia," nor did the former contain any structures resembling cercariae or even germ balls, so that they may have arisen from a later infection.

The walls of the larger rediae have orange colouring; the intestine is generally a darker orange and sometimes black in parts, and extends about two-thirds of the body length, to, or just beyond, the foot processes. The pharynx is often situated in a small anterior prolongation. The collar consists of four prominences connected by a slight ridge. Beaver (1937, 13) noted, for rediae of *Echinostoma revolutum*, that the pharynx and gut changed in relative size as the rediae increased in total length, that the collar became less conspicuous in the mother rediae, and that the walls of rediae of the "daughter" generation contained no yellow pigment. These observations also apply to rediae of *Paryphostomum tenuicollis*.

Rediae may persist within the snail host from one season to the next; four snails obtained in the summer or autumn of 1941 were still emitting cercariae when retested in the spring (October), and continued to do so until they died in November.

## CERCARIA

The cercariae are evidently released from the redia some time before they emerge from the snail, for snails which are killed and dissected immediately afterwards show numerous cercariae free in the liver. The free-swimming life is of less than 24 hours' duration. The swimming action is typical, though microscopically the tail appears somewhat longer than that of the average echinostome.

Size of ten specimens preserved with boiling 10% formalin: length 220-300  $\mu$  (average 250  $\mu$ ); breadth at widest point 117-150  $\mu$  (average 128  $\mu$ ); length of tail 350-500  $\mu$  (average 434  $\mu$ ); breadth of tail 38-50  $\mu$  (average 43  $\mu$ ).

The collar and its spines are described for the metacercaria, in which stage the spines can be counted more satisfactorily, since it is usually difficult to do so in the cercaria.

The cuticle is slightly roughened, but there is no noticeable spination. The whole body, with the exception of the two suckers, stains evenly with neutral red; the tail itself stains only faintly, but its many nuclei appear dark and granular.

The cystogenous cells are a characteristic feature; they contain yellowish rod-like granules which lie parallel in from one to three groups in each cell. The cells themselves lie roughly in four main longitudinal groups, one on each side of the main arms of the bladder. Gland cells are not visible even with intra-vital staining, but in the region surrounding the oral sucker traces of ducts are occasionally seen. On either side of the anterior end of the prepharynx, two or three greenish refractive bodies are regularly present (see fig. 1).

Both suckers are provided with a transparent frill which is an extension of the cuticle. The acetabulum is a deep cup and is very prominent in lateral view. It is larger than the oral sucker. Measurements from five cercariae cleared in glycerine were: oral sucker  $42\mu$  transversely by  $38\mu$  lengthways; acetabulum  $70\mu$  by  $55\mu$ , the ratio of transverse diameters being 3:5, and that of lengths about 5:7.

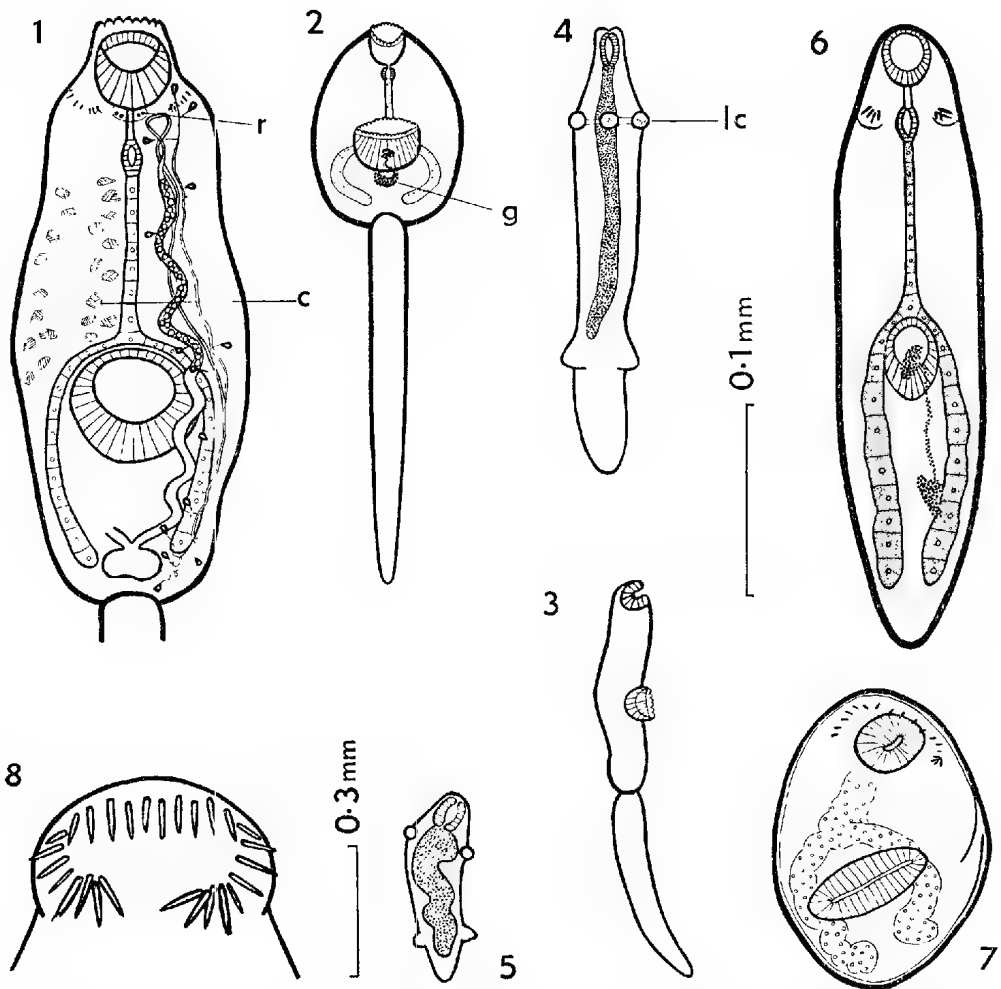


Fig. 1-7, *Cercaria Paryphostomi-tenuicollis*: 1, glycerine mount, with some details from living cercaria incorporated, cystogenous cells shown only in one quadrant of body; 2, stained preparation; 3, formalinised specimen, side view; 4, "mother" redia; 5, "daughter" redia; 6, metacercaria, stained preparation; 7, cyst (glycerine). Fig. 8, *Paryphosomum tenuicollis*, collar spines. Fig. 1, 6, 7, to same scale; fig. 4, 5, 8; 3, sketch. c, cystogenous cells; g, genital anlage; l.c., lobes of collar; r, refractive bodies.

Prepharynx short, pharynx relatively small; walls of oesophagus composed of seven or eight large cells with clear, non-granular nuclei. Each crus is narrow in the region anterior and antero-lateral to the acetabulum, but broadens out posteriorly. The crura show the same type of cellular structure as the oesophagus.

The main arms of the bladder in the region anterior to the acetabulum contain about thirty fairly large excretory granules, there being one or two across the diameter of the tubes. The junction of anterior and posterior collecting tubes is at the mid-acetabular level. The total number of flame cells is probably thirty, composed on each side of two groups of three opening into the posterior collecting tubule, with one group of three and six single flame cells opening into the anterior tubule. The formula can therefore be expressed as probably  $2 \mid (6 + 3) + (3 + 3) \mid$ . No flames were seen in any of the excretory tubes. The excretory pore opens dorsally near the posterior border of the bladder; no excretory tube has been seen in the tail.

The reproductive anlage is indicated in fig. 2. The tail has no fin-fold.

#### CYST

*Cercaria Paryphostomi-tenuicollis* has been found experimentally to encyst beneath the scales and in the sub-cutaneous tissues, mainly in the head region, of the aquarium fish, *Carassius auratus*, *Phallocheras caudomaculatus*, *Barbus* sp., *Gambusia affinis* and *Oryzias latipes*; and beneath the skin of tadpoles of *Pseudophryne bibroni*. It does not encyst in the molluscs, *Planorbis isingi*, *Limnaea lessona*, *Amerianna pyramidata*, *A. pectorosa*, *A. tenuistriata* or *Corbiculina angasi*; in the leech, *Glossiphonia* sp. or in the common planarian (? *Dalyellia*). It has been found as a natural infection in the following fish from the Tailem Bend swamps: *Carassius auratus*, *Pseudophryne urvillii*, and *Tandanus tandanus*.

The cysts may be round, but are generally slightly elliptical, the average of ten living specimens being 170 by 140  $\mu$  (range 160 to 184  $\mu$  long, 134 to 150  $\mu$  wide).

#### METACERCARIA

The collar and body spination have become much more definite since the cercarial stage, but otherwise there is little further development apparent, although the difficulty of excysting metacercariae undamaged prevented as detailed study being made as was possible with the cercaria. The body spines extend over the whole body, but are more prominent anteriorly. The collar spines total 27; on each side there is a corner group of 4, followed by three or four, forming the "shoulder," and the remaining (dorsal) spines are arranged alternately, the two series being uninterrupted. The corner spines are about 19  $\mu$  long; sometimes one, sometimes two, of the group appear to be shorter (about 15  $\mu$ ). The first shoulder spine is regularly smaller than any others, being about 12  $\mu$  long; the next two show a gradual increase towards the size of the dorsal spines. These latter could not be measured accurately because of fore-shortening caused by the position in which the metacercaria seemed to be fixed on liberation from the cyst.

Attempts to obtain the adult stage experimentally by feeding cysts to various birds—three pigeons, a fowl and a canary—gave negative results in all cases.

#### RELATIONSHIPS

From the descriptions of cercariae with 27 spines to which we have had access, *Cercaria Paryphostomi-tenuicollis* shows the closest resemblance to *C. Euparyphii-melis*, described by Beaver in 1941. The latter appears to be definitely larger, but in most anatomical features it is extraordinarily like our cercaria. The rediae of the two forms are also similar in having a four-lobed collar, though in Beaver's form the collar is stated to be completely divided into

four lobes, while in the redia of *Paryphostomum tenuicollis* the lobes appear to be connected. From the similarity in the life history stages it seems obvious that the genera *Euparyphium* and *Paryphostomum* must be closely related, and indeed, the general appearance of *P. tenuicollis* and Beaver's figures of *Euparyphium melis* is similar. The main characters distinguishing the two genera are the presence, in the latter, of markedly lobed testes; large, very muscular acetabulum, which is elongated posteriorly; and the small cirrus sac which lies mainly in front of the acetabulum.

#### SUMMARY

- 1 *Paryphostomum tenuicollis* is shown experimentally to have its redia stage in *Amerianna* spp. *Limnaca lessoni* is parasitised by a cercaria which is regarded as belonging to the same species.
- 2 The various stages in the life history are described.
- 3 The cercaria is a 27spined form which is a common parasite of *Amerianna* spp. in the Taillem Bend swamps, and is also recorded from two other localities in South Australia.
- 4 The cyst stage occurs in various freshwater fish, and less commonly in tadpoles.
- 5 The occurrence and distribution of the adult from various species of *Phalacrocorax* are listed.
- 6 A description of the collar spination of the metacercaria and adult is given.

We desire to make the usual acknowledgments: to the Commonwealth Research Grant to the University of Adelaide; to Messrs. G. and F. Jaensch, and L. Ellis, of Taillem Bend; as well as to Mrs. E. R. Simpson, who carried out a preliminary study on the cercaria.

Slides of all stages described in this paper, and in others of the series dealing with trematode life cycles, have been deposited in the South Australian Museum.

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# **AUSTRALIAN GASTROPODA OF THE FAMILIES HYDROBIIDAE, ASSIMINEIDAE AND ACMEIDAE**

By BERNARD C. COTTON

## **Summary**

In this paper the genera and species of the difficult families Hydrobiidae, Assimineidae and Acmeidae are discussed, and an effort is made to decide which genera are correctly used for the Australian species, which are valid and which are synonyms. Each genus listed is followed by the author, date, genotype, locality and distribution. The first locality is that of the type.

## AUSTRALIAN GASTROPODA OF THE FAMILIES HYDROBIIDAE, ASSIMINEIDAE AND ACMEIDAE

By BERNARD C. COTTON

[Read 13 August 1942]

### PLATE IV AND V

In this paper the genera and species of the difficult families Hydrobiidae, Assimineidae and Acmeidae are discussed, and an effort is made to decide which genera are correctly used for the Australian species, which are valid and which are synonyms. Each genus listed is followed by the author, date, genotype, locality and distribution. The first locality is that of the type.

### Family HYDROBIIDAE

Genera represented in Australia and Tasmania are *Tatea*, *Petterdiana*, *Tasmaniella*, and *Austropyrgus* gen. nov. The species of *Tatea* have been dealt with in the previous part of this journal (66, (1), 81). The whole of the species of the other three genera are here reviewed. An extensive representative series of the numerous Tasmanian species of this family is in the May Collection, which was purchased some years ago by Sir Joseph Verco and presented to the South Australian Museum.

#### Genus PETTERDIANA Brazier 1895

*Petterdiana* Brazier 1895, Proc. Roy. Soc. Tasm., 105. Genotype *Ampullaria tasmanica* Tenison Woods 1876, North Tasmania.

*Brazieria* Petterd 1888, Proc. Roy. Soc. Tasm., 76 (same genotype). nec *Brazieria* Ancey 1887, Conch. Exch., 2, 22.

*Pseudampullaria* Ancey 1898, Bull. Mus. Marseille, 1, 147.

*Distribution*—Northern Tasmania.

The generic description reads: "Shell globosely rounded, imperforate; spire small, body-whorl large; aperture very oblique, effuse; outer lip acute, inner lip thickened; operculum horny, subspiral. Animal, ?" Conchologically this genus is closely allied to the next, *Tasmaniella*, but differs in the more globose shell with shorter spire.

Species recorded are: *Petterdiana paludinca* Reeve 1857, "Tasmania" (= *tasmanica* Tenison Woods 1876, North Tasmania = *tasmaniae* Tate and Brazier 1881, Tasmania); *tasmanica* Tenison Woods 1875, Goulds Country, North-East Tasmania.

#### Genus TASMANIELLA Ancey 1898

*Tasmaniella* Ancey 1898, Bull. Mus. Marseille, 1, 148. Genotype *Amnicola launcestonensis* Johnston 1878, North Tasmania.

*Beddomia* Petterd 1888, Proc. Roy. Soc. Tasm., 73, genotype *B. launcestonensis* Johnston 1878, preocc., *Beddomia* Neville 1878, Hand List Moll. Ind. Mus., 1, 127, for a land snail.

*Distribution*—Northern Tasmania.

This genus appears to have been overlooked by Australian and Tasmanian conchologists. Whether it will survive as a separate genus or will be placed as a synonym of the previous one is a matter to be decided by future study. Species we allot to this genus are: *Tasmaniella launcestonensis* Johnston 1878, Launceston and South Esk River; *minima* Petterd 1888, stream near Heazlewood River, North-west Tasmania; *hullii* Petterd 1888, stream near Heazlewood River; *lodderae* Petterd, creek near Upper Castra, River Leven, North-west Tasmania.

**Austropyrgus** gen. nov.

Genotype *Paludina nigra* Quoy et Gaimard 1935, from small freshwater creeks, D'Entrecasteaux Channel, Tasmania.

*Distribution*—South Australia, Victoria, New South Wales, and Tasmania.

Shell small, moderately elongated, pointed, whorls four and a half, convex, typically smooth though sometimes more or less sharply carinated or even bearing a spiral line of interrupted pointed spines, variations which might occur in the same species in different localities or may be all represented in the one species in the one pool; in stagnant or still water the shell may be black due to an external coat of decaying vegetable matter, whereas in clear running water the shell is pale yellowish horn-coloured and subtranslucent. Operculum thin, corneous, paucispiral. Animal with a narrow foot which is expanded in front, opaque, white shaded with very pale bluish-grey, tentacles and rostrum shaded with dark bluish-grey; tentacles long, slender and pointed; eyes plainly visible under the lens at the outer base of the tentacles; rostrum thick, projecting and wrinkled; radula with central basal lobe of the rachidian tooth much produced, first lateral very much bent bearing twelve round denticles, second lateral bearing similar denticles which are however in this genus separated and number eleven, marginal tooth with five obsolete denticles; formula of denticles  $9/3.3-12-11-5$ .

Australian and Tasmanian species of this genus have been erroneously placed in various non-Australian genera such as *Hydrobia*, *Bythinella*, *Bythinia*, *Potamopyrgus*, all of which show some conchological similarity but considerable dissimilarity in the animal. A brief description of some of these genera, based on their genotypes is here given to show that minute examination of the animal is essential to the classification of certain groups of freshwater shells. The New Zealand genus *Potamopyrgus* is probably the most nearly related to *Austropyrgus*.

*Hydrobia* Hartmann 1821. Genotype *Hydrobia acuta* Draparnaud, Europe. Shell ovate, smooth, elongate, subperforate, whorls flattened, apex acute; operculum corneous; animal with foot somewhat pointed behind, rostrum rather long, tentacles somewhat tapering but blunt at the extremity, verge (male organ) simple; radula with rachidian tooth broad with a central basal process; formula long, tentacles somewhat tapering but blunt at the extremity, verge (male organ) of denticles  $7/1.1-6-13-25$ . *Distribution*—Northern Hemisphere.

*Bythinella* Mcuquin-Tandon 1855. Genotype *Bulinus viridis* Poirer, Europe. Shell smooth, elongated, imperforate, whorls rounded, apex obtuse; operculum corneous with the nucleus moderately large; animal with foot rather narrow, rounded behind, rostrum moderately long, tentacles tapering but blunt at the tip, verge typically bifid; radula with rachidian tooth moderately long, with the infero-lateral angles much produced, first lateral with the body longer than broad; formula of denticles  $9/1.1-6-18-0$ . *Distribution*—Europe and North America. Incidentally there appear to be at least two names which have priority. They are *Microna* Ziegler 1852 and *Frauenfeldia* Clessin 1879. Some authors quote *Bythinella* as 1851, but it does not seem to have been correctly introduced as a latinised scientific name until 1855.

*Potamopyrgus* Stimpson 1865. Genotype *Annicola corolla* Gould 1852. Shell short, whorls coronated with spines, imperforate, apex acute; operculum corneous; animal with foot rather short, broadest in front and strongly auriculated, rostrum moderately long, tentacles very long slender tapering and pointed, verge ?; radula with rachidian tooth trapezoidal, first lateral with a very long peduncle, third lateral with summit shaped like a chopping-knife; formula of denticles  $9/4.4-11-15-20$ . *Distribution*—New Zealand, freshwater.

The species belonging to the genus *Austropyrgus* are as follows:

(a) Rivers of Victoria and Northern Tasmania, and Eastern New South Wales.

*Austropyrgus buccinoides* Quoy and Gaimard 1835, Western Port, Victoria, brackish swamps (= *victoriae* Tenison Woods 1878, Lake Connemawarre, Geelong, Victoria — *angasi* Smith 1882, Compasely River, Victoria); *ruppiac* Hedley 1912, Deewhy Lagoon, a few miles north of Sydney, seems closely allied to the preceding; *grampianensis* Gabriel 1939, Dairy Creek, near Silver Band Falls, Grampians, Victoria; *tasmanica* Von Martens 1858, North Tasmania (= *diemenense* Frauenfeld 1865, North Tasmania = *dulvertonensis* Tenison Woods 1875, Lake Dulverton, North Tasmania = *woodsii* Petterd 1888, South Esk River, North Tasmania); *petterdiana* Brazier 1875, Emu Bay, North Tasmania (= *nigra* Gabriel 1939, Victoria); *brownii* Petterd 1879, stream at Long Bay, North-east Tasmania; *elongatus* May 1920, Apsley River, near Bicheno North, East Coast, Tasmania; *marginata* Petterd 1888, stream near the Heazlewood River, tributary of the Whyte, North-west Tasmania; *smithii* Petterd 1888, Heazlewood River, also Arthur, Waratah and Castray Rivers, on stones, North-west Tasmania; *brazieri* Smith 1882, South Grafton, Clarence River, New South Wales; *petterdi* Smith 1888, Richmond River, New South Wales; *hyalina* Brazier 1875, Eastern Creek, New South Wales, distributed about Parramatta and Chatsworth; *vertiginosa* Frauenfeld 1862, "New Holland," probably New South Wales; *schraderi* Frauenfeld 1862, "Australia"? probably New South Wales. The last three species may prove to belong to another genus, as the operculum of at least one of them (*australis*) is calcareous, and it is quite probable that the other two have a similar type of operculum.

(b) Rivers of South Tasmania.

*Austropyrgus nigra* Quoy and Gaimard 1835, D'Entrecasteaux Channel, South Tasmania, widely distributed (= *unicarinata* Tenison Woods 1875, ? South Tasmania = *tasmanica* Tenison Woods, Hobart, South Tasmania = *legrandi* Tenison Woods 1875, Browns River = *exigua* Tenison Woods 1879, nom. nov. for *legrandi* = *legrandiana* Brazier 1871, Salmon Ponds, New Norfolk = *wisemaniana* Brazier 1871, creeks near Hobart; all varieties or direct synonyms and all from South Tasmania); *gunnii* Frauenfeld 1863, South Tasmania (= *simsoniana* Brazier 1871, Hobart, Tasmania — *pontcillensis* Tenison Woods 1875, Jordon River, near Brighton, South Tasmania = *dunrobinensis* Tenison Woods 1875, from the Ouse, near Dunrobin); *turbinata* Petterd 1888, River Styx, tributary of the Derwent, South Tasmania.

(c) Rivers of South Australia.

*Austropyrgus pattisoni* Cotton 1842 (*Bythinella*) River Torrens at Paradise Park, South Australia; the Victorian species *buccinoides* occurs in the South-East of South Australia. We have it from Eight Mile Creek, in that area.

#### Genus GABBIA Tryon 1865

*Gabbia* Tryon 1865, American Journ. Conch., 1, 220. Genotype *Gabbia australis* Tryon 1865, New South Wales.

#### *Gabbia iredalei* sp. nov.

(Pl. iv, fig. 3, 4, 5)

Shell small turbinate, smooth; whorls globose, apex obtuse and eroded in some specimens, lines of growth slightly irregular, fine; umbilicus minute, aperture oblique; operculum paucispiral, horny but slightly calcareous, with a central nucleus.



*Holotype*—Height 7 mm., width 5.5 mm., D. 14098, S. Aust. Museum, Storm Creek, Central Australia.

*Distribution*—Central Australia, Storm Creek, Oodnadatta, etc.

This species is distinguished from the New South Wales genotype by the difference in general shape and comparatively greater width.

#### Family ASSIMINEIDAE

A few Australian species have been placed in the genus *Assiminea* the genotype of which is European, and other species are recorded from Asia and America. Subgenera have been introduced for Indian and Chinese species, while *Met-assiminea* Thiele 1927, genotype *M. philippinica* Boettger, is recorded from the Philippines and Australia. Australian species are here placed in the typical genus *Assiminea*, though there is some doubt as to the correctness of regarding our species as belonging to this genus.

#### ASSIMINEA Fleming 1928

*Assiminea* Fleming 1828, Hist. Brit. Anim., 275. Genotype *A. grayana* Fleming 1928, Naples.

*Distribution*—European.

Conchologically there is not much difference between the Australian and European species, and still more remarkable is the similarity of the radula of the genotype and *A. tasmanica* Tenison Woods.

Australian species are marine, estuarine and amphibious. They are here listed.

*Assiminea granum* Menke 1843, Swan River, Western Australia, among white quartz sand; this species is common in South Australia, where it is frequently found living in the tidal influence of rivers. We have found it from Robe, Henley Beach, Venus Bay, Beards Bay, Murat Bay, Denial Bay, American River, Kingston, Streaky Bay also dredged specimens from 35 fathoms, off St. Francis Island, and at localities in Western Australia such as King George Sound, and Albany; *tasmanica* Tenison Woods 1876 Sorell, North Tasmania, in shallow inlets and mudflats, amphibious also from Port Phillip, Port Fairy, and Warrnambool, Victoria, and coastal New South Wales, and also Port River and Gulf St. Vincent, South Australia (= *Rissoa siennae* Tenison Woods 1876, North Coast, Tasmania = *A. bicincta* Petterd 1888, mouth of the River Don, North Coast, Tasmania, "obtained living on stones and grass within the influence of the tide in company with *Tatea rufilabris*," i.e., *huonensis* — *australis* Tate 1888, Kelso, Tamar Heads, North Tasmania); *brazieri* 1875, Isthmus Bay, Bruny Island, South Tasmania, "very plentiful entangled in confervoid growths on rocks" described as a *Rissoina*; *pagodella* Hedley 1903, Manly Lagoon, New South Wales, in brackish water.

#### *Assiminea relata* sp. nov.

(Pl. iv, fig. 1, 2)

*Assiminea affinis* Mousson 1874, Cat. Godeffroy Museum, 5, 103, nom. nud.

*Holotype*—Height 5 mm., width 3 mm., Burleigh Heads, Queensland, D. 14099, S. Aust. Museum.

This species is more elongate and of a different shape from *A. tasmanica*.

#### Family ACMEIDAE

About a dozen genera from various parts of the world are placed in this family, and three, *Acmea*, *Coxiella*, and *Coxielladda*, are represented in Australia.

## Genus ACMEA Hartmann 1821

*Acmea* Hartmann 1821, *Neue Alpina*, 1, 204. Genotype *A. truncata* Hartmann (designated Iredale 1915).

*Truncatella* Risso 1826, II, N. Europe, 4, 124. Genotype *T. subcylindrica* Linn.  
*Truncatula* Leach 1847, *Ann. Mag. Nat. Hist.*, 20, 271. Genotype *T. truncata*.

***Acmea vincentiana* sp. nov.**

(Pl. v, fig. 11-13)

*Truncatella marginata* Cox 1868, *Mon. Aust. Land Shells*, 92; Verco 1912, *Trans. Roy. Soc. S. Aust.*, 36, 203, nec Kuster 1885.

*Acmea marginata* (May 1921), *List Moll. Tas.*, 57.

*Holotype*—Height 6.3 mm., width 2.25 mm., Glenelg, South Australia, D. 14106, South Australian Museum.

*Distribution*—Geraldton, Western Australia, South Australia to Victoria and Northern Tasmania, Recent and Pleistocene.

Shell pyramidal in the juvenile, with an obtuse apex, and in the adult sub-cylindrical with a domed apex; shining, smooth, amber-coloured or pale translucent flesh-coloured in life, with a narrow smooth semi-opaque white subsutural band; adult whorls four to five, a little convex, finely sculptured with axial accretional striae but otherwise smooth; aperture vertical, angularly oval, broadened slightly at the base, peristome continuous, rather expanded; operculum subspiral.

This species was first described and figured by Cox in 1868 from Port Lincoln, South Australia, but he identified it as *marginata* Kuster 1855, a different species described from Labuan, Borneo. The only similarity between that species and *vincentiana* is the tendency to smooth whorls and lack of prominent axial sculpture so common in this genus. The present species differs in the more bulbous shape of the whorls, the much more strongly developed aperture and the tendency to the formation of an opaque white band below the suture; on looking through a large series of specimens from the Flindersian Region there seems sufficient evidence to suspect that more than one species of "smooth" *Acmea* exists.

Found in great numbers along the Southern Australian coastline as a Pleistocene fossil on the raised beaches, and Recent from Western Australia to Western Victoria and also Northern Tasmania. Other species are *scalarina* Cox 1868, Port Lincoln, South Australia (= *Truncatella tasmanica* Tenison Woods 1876, Bass Strait = *Turbonilla tasmanica* Tenison Woods 1876, King Island, Bass Strait = ? *micra* Tenison Woods 1878, Brighton, Victoria). Also occurs in the Recent and Pleistocene from Geraldton to Victoria and is common at certain places on Kangaroo Island; *valida* Pfeiffer 1846, New South Wales (= *brasieri* Cox 1868, Millers Point, Sydney, New South Wales), distributed along the New South Wales and eastern Victorian coast; *ferruginea* Cox 1868, Cape York, North-East Australia, distributed along the Queensland coast and Northern Territory; *teres* Pfeiffer 1856, Trinity Bay, North-East Australia, distributed along the eastern coast of Queensland; *yorkensis* Cox 1868, Cape York, north and eastern coasts of Queensland.

In life the shell of *A. scalarina* may be translucent, transparent or horn-coloured, and when dead it may be white, salmon tint or bleached. The juvenile shell is narrowly pyramidal, whorls round, apex blunt, axial ribs numerous, fading rapidly at the periphery of the last whorl the base of which is smooth, aperture without a definite outer lip which is broken and occasionally corresponds with the curved axial sculpture, general shape of the aperture vertically oval, very slightly channelled at the base; adult shell more solid and may be nearly cylindrical or



1



2



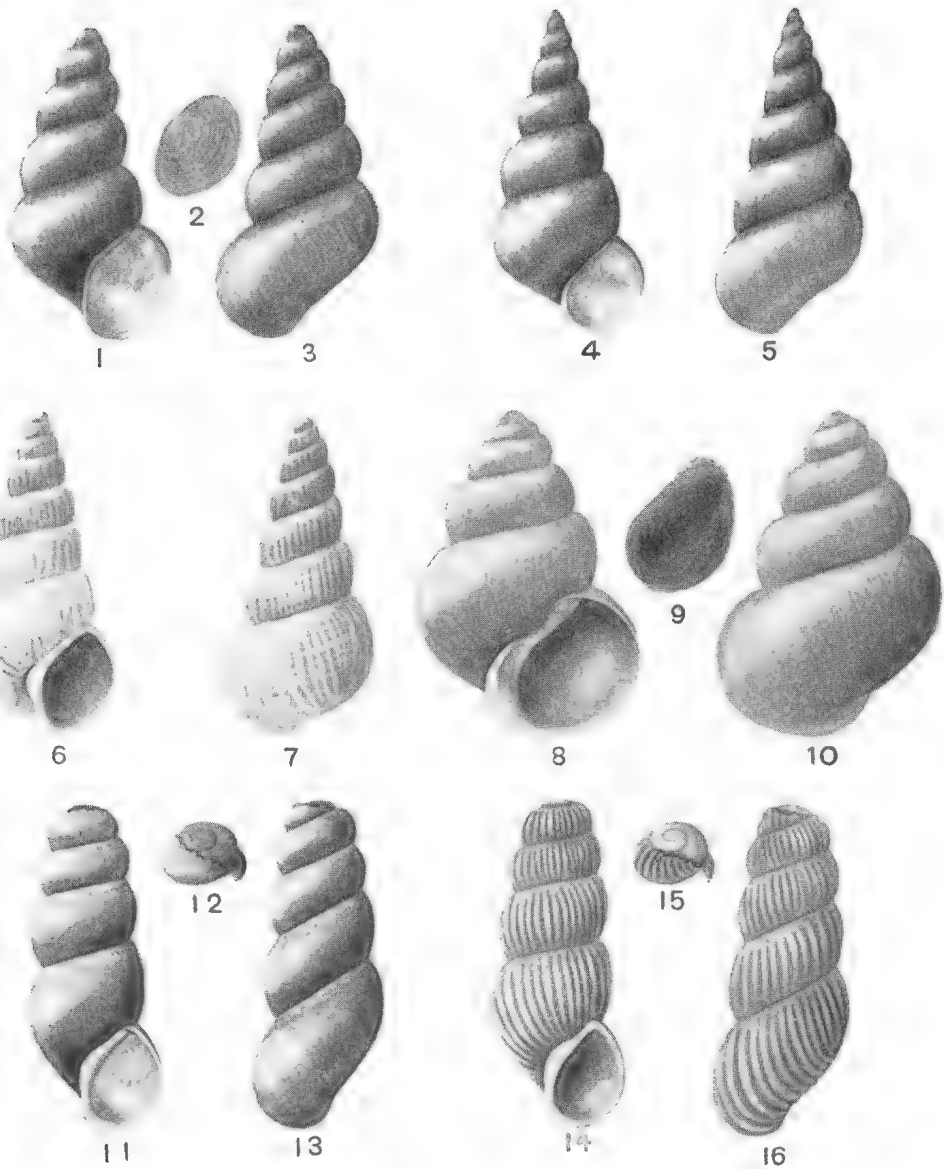
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4



5



slightly increasing in width with age, axial ribs extending over the base, margin of mouth projecting with a thick inner lip reflected at the lower part to form a slight angle with the base of the shell. The apex of the shell has a ragged margin forming a collar, with a low smooth round dome-shaped top closing the opening within. The eyes are behind the pedicle which is 2 mm. long, head pale pink, pedicle lead grey, body white, operculum resembles a *Halotis* shell. This species crawls at the rate of 38 mm. to 45 mm. per minute on a dry, smooth-planed, pine board, the movement being peculiar; the head is advanced, then the shell dragged up with a roll to the left at the end of the movement, when the short foot is drawn up. About 15 to 18 of these steps are taken per minute; all but two out of eighty specimens moved away from the light.

#### Genus COXIELLA Smith 1894

*Coxiella* Smith 1894, Proc. Mal. Soc., 1, 98. Genotype, *Truncatella striatula* Menke.

*Blundfordia* Cox 1868, Mon. Aust. Land Shells, 94. Same genotype, preocc., Adams 1863,. Genotype *Blundfordia japonica* Adams.

*Coxiella striatula* Menke 1843, South-western Australia (= *pyrrhostoma* Cox 1868, Sharks Bay, Western Australia), is found as far east as Streaky Bay, South Australia, though the specimens from the last locality, judging by their appearance, may be raised beach fossils; *filosa* Sowerby 1838, Mitre Lake, Western Victoria (= *striata* Sowerby 1842, same locality = *striatula* Angas 1863, Adelaide, South Australia = *confusa* Smith 1898, Adelaide, South Australia, *nom. nov.* for *striatula* Angas 1863, preoc. by *striatula* Menke 1843), common in South Australia, particularly in the South-East, Coorong, Yorke Peninsula and Kangaroo Island, where countless millions of shells form reefs. It is the dominant shell in the marl found in the vicinity of the Torrens Reed Beds at Fulham, South Australia. We have it from the stomach contents of mullet and whiting caught off our coasts; there are specimens in the South Australian Museum Collection from Cowangatta, near Mount Corambra, New South Wales.

#### Genus COXIELLADDA Iredale 1938

*Coxielladda* Iredale 1938, S. Aust. Nat., 18, (3), 66. Genotype *Paludina gilesi* Angas 1877.

Only the name and genotype is cited in the above reference. The species differs from those of *Coxiella* in being short and globular in shape and is found only in Central Australia, Far North of South Australia and Western Australia.

*Coxielladda gilesi* Angas 1877, shores of Lake Eyre, South Australia (= *stirlingi* Tate 1894, Lake Callabonna); *mammillata* Smith 1898, on the shore of a dry salt lake near Nannine, Murchison Goldfield, Western Australia; closely allied to the preceding species.

### DESCRIPTION OF PLATES

#### PLATE IV

Fig. 1, 2, *Assiminea relata* n. sp., x 17: 1, ventral; 2, dorsal, Fig. 3-5, *Gabbia iredalei* n. sp., x 11; 3, ventral; 4, operculum; 5, dorsal.

#### PLATE V

Fig. 1-3, *Austropyrgus gumii*, x 14: 1, ventral; 2, operculum; 3, dorsal. Fig. 4-5, *Austropyrgus elongatus* x 14: 4, ventral; 5, dorsal. Fig. 6-7, *Coxiella filosa* x 4.5: 6, ventral; 7, dorsal. Fig. 8-10, *Coxielladda gilesi* x 6: 8, ventral; 9, operculum; 10, dorsal. Fig. 11-13, *Acmea vincentiana* n. sp., x 8: 11, ventral; 12, adult apex; 13, dorsal. Fig. 14-16, *Acmea scalarina*: 14, ventral; 15, adult apex; 16, dorsal.

# **AN EXAMINATION OF A SAMPLE OF LEIGH CREEK COAL**

By W. TERNENT COOKE

## **Summary**

In a "Record of the Mines of South Australia," issued in 1899, the Government Geologist states (11) that the Leigh Creek coalfield had been officially visited by himself in February 1889. Since that date the field has been explored by drilling, coal has been raised, full-scale combustion tests, producer-gas tests, laboratory scale distillation tests have been made, and reports thereon published (6, 31), (8, 35). Many proximate analyses, including sulphur content, have been published (6, 31), (8, 26-48), but data relating to a more detailed chemical examination of the coal seem lacking. The present paper aims at supplying a few such data for a sample obtained from one of the recently drilled bores. The sample in question, designated E.1., was kindly made available to me by the Director of Mines. About twenty pounds weight of fines were supplied; these were mixed, quartered, and sampled in the usual manner.

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[Read 13 August 1942]

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## MOISTURE

The moisture content varies markedly according to conditions of storage, air humidity, etc. (6, 33). The sample, when first prepared, gave a value of 19.3% by the distillation method, using toluene, and 19.4% by drying at 110° C. Later, in the proximate analyses, the value found was 17%. Complete desiccation by heating is slow, and the dried coal is markedly hygroscopic. A small sample with 2% of moisture was left exposed in the laboratory. After six days a moisture content of 12% was reached, and for 23 days oscillated between this value and 10.4%. Figures for moisture content after exposure under summer conditions at Leigh Creek would be of interest. The hygroscopic nature of the coal suggests that it might serve as a suitable raw material for the preparation of active carbon for use as a drying agent and as an absorbent of vapours.

## THE ASH

The percentage found, as in the ultimate analysis, is 20.5. The ash is nearly white in colour, as might be expected from the low iron content of the coal, but becomes slightly darker when strongly heated. Attack by strong hydrochloric acid gave the values: insoluble, 49.26%; oxides of iron, alumina, etc., 33.89%; calcium oxide, 7.05%; magnesium oxide, 2.49%; total, 92.69%. The insoluble included 39.57% of actual  $\text{SiO}_2$ , and some titania. Attack with fused alkali carbonates, in conjunction with other estimations, gave the values:

$\text{SiO}_2$	-	-	-	39.30%
$\text{Fe}_2\text{O}_3$	-	-	-	2.97
$\text{Al}_2\text{O}_3$	-	-	-	35.51
$\text{TiO}_2$	-	-	-	2.18
$\text{P}_2\text{O}_5$	-	-	-	1.11
$\text{CaO}$	-	-	-	6.73
$\text{MgO}$	-	-	-	3.24
$\text{Na}_2\text{O}$	-	-	-	6.34
$\text{K}_2\text{O}$	-	-	-	.44
$\text{SO}_3$	-	-	-	2.65
Cl	-	-	-	.28

100.75 less 0.07% of oxygen equivalent  
to 0.28% of chlorine.

Manganese also is present in the ash in small quantities.

Dalwood reports (9, 10) a softening point of 1,290° C. and slagging at 1,410° C. It is stated also (6, 32) that the coal clinkered badly when used on a locomotive, and on a steam tug. These statements are not surprising considering the high content of bases in the ash, and clinkering would probably have been more noticeable if the percentage of iron were not so low.

#### NITROGEN

Two estimations by the Kjeldahl method were made, using (a) sulphuric acid and potassium sulphate, and (b) sulphuric acid with a little selenious acid. The latter method of digestion is much quicker. The results were 1.07, and 1.28, mean 1.17%.

#### SULPHUR

Two assays by the Eschka method gave a mean of 0.28% for total sulphur. For the sulphur distribution four determinations were made, two by Powell's method (10), and two by that of the British Standards Institution (2). These methods differ only in minor details. Results are shown in Table I.

TABLE I  
Sulphur Distribution

			(a) Sulphate		(b) Pyritic		Organic
			S.	Fe	S.	Fe	-28 - (a + b) S.
Percent	-	-	.09	.451	.068	0.049	.122
Atomic ratio	-	-	.346	1.0	2.4	1.0	

#### CHLORINE

Using the method given under (2), two determinations gave the values 0.547 and 0.543%.

#### PROXIMATE ANALYSES

The results for the present sample are shown in Table II in the first and second columns. For the sake of comparison there is given in columns three and four the average value of 21 samples from a previous boring (8, 26).

		Proximate Analyses			
Moisture	-	-	17.69	20.00	
Volatile	-	-	26.68	32.42	25.50
Fixed carbon	-	-	38.65	46.97	36.40
Ash	-	-	16.98	20.64	18.08
			<hr/>	<hr/>	<hr/>
			100.00	100.03	99.98
					100.00

#### TRUE MINERAL MATTER

Using the calculations given by King (5), the ash as found, 20.5%, corresponds to 19.96% mineral matter.

#### ULTIMATE ANALYSIS

The results shown in Table III are for moisture-free coal, and are calculated also for ash and moisture-free coal. In accordance with the suggestion of King (5), one-half of the chlorine content of the coal is taken as being of organic origin.



Ultimate Analyses				
Carbon	-	-	56.65	70.82
Hydrogen	-	-	3.67	4.59
Nitrogen	-	-	1.17	1.46
Organic S.	-	-	.12	.15
Organic Cl.	-	-	.27	.34
Mineral	-	-	19.96	
Oxygen (diff.)	-	-	18.16	22.70
			<hr/> 100.00	<hr/> 100.06

C/H = 15.4  
C/O = 3.12

## OBSERVATIONS

The coal is spoken of as a sub-bituminous coal, allied to that of Ipswich, Queensland (14). Judging from the analyses and the ratios between carbon, hydrogen, and oxygen, calculated on an ash-and-moisture-free basis, it would seem to be rather a lignite than a bituminous coal (1), or at least to lie on the borderland between these two classes. Hickling's classification (4) would place it in this borderland, and Seyler's (12) (13) would place it definitely as a lignite, as also would Wheeler's (15). The coal forms a red mass when warmed with nitric acid, gives a dark brown solution with hot caustic soda, has a high (and variable) water content (6, 33), a low calorific value (6, 34), in short has the characteristics associated with coals of the lignite type.

As a fuel it is distinctively of higher grade than any of the hitherto known deposits in the State, and its low sulphur content is a distinct asset to its utilisation. The chlorine content is quite high, much higher than that of Moorlands lignite (3), and if characteristic of the general run of the coal, it may be the cause on big scale usage of unpleasant corrosion. Comparing figures for chlorine content of ash and coal, it is seen that approximately 90% of the chlorine has been volatilized on combustion.

In assessing the possible utility of the coal the following extract from a summary report on the utilization of the coal may be noted (6, 36). "... it is felt that special stress should be laid upon the fact that all the working trials, of whatsoever character, performed have been made in plants designed for the consumption of a higher grade of coal. It is not reasonable to expect that the best attainable results can be secured with the use of boilers built for raising steam with bituminous coal of normal character. The type of grates employed and the areas of the fireboxes were not specially adjusted for this particular coal. The results hitherto obtained may be therefore considered capable of material improvement."

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# **TRENDS IN THE YIELDS OF FALLOW-SOWN AND STUBBLE-SOWN CEREALS IN SOME SOUTH AUSTRALIAN EXPERIMENTS**

By D. C. WARK, M.Agr.Sc., Waite Agricultural Research Institute

## **Summary**

The results of rotational and manurial experiments are commonly expressed as mean yields for the period of the experiment, but it is important to consider whether the yields have been increasing or decreasing with time.

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[Read 13 August 1942]

The results of rotational and manurial experiments are commonly expressed as mean yields for the period of the experiment, but it is important to consider whether the yields have been increasing or decreasing with time.

Klages (3) determined the trends in the yields of crops in ten rotations for 23 years at the University Farm, Idaho, U.S.A. He found that the trend of wheat and oat yields was upward for the high-yielding plots and stationary or downward for the low-yielding plots. As there was no marked trend in the incidence of rainfall over the same period, he concluded that the observed trends

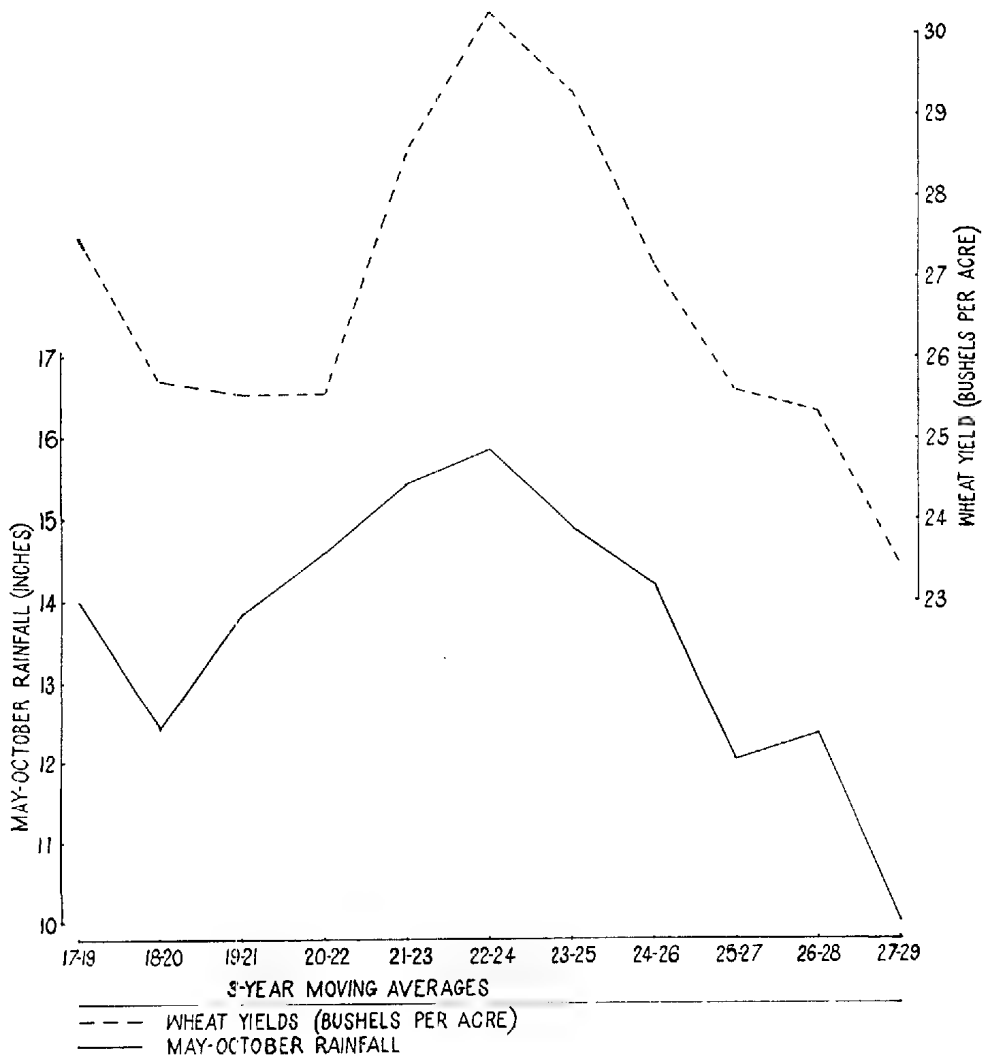


Fig. 1

Comparison of yield of wheat on fallow at Booborowie with May-October rainfall.

resulted from changes in soil fertility. Forster (2) determined the trends in yields of wheat and oats in rotation experiments at three places in Victoria. He adjusted the yields for rainfall, using the method of partial regression. Whilst the wheat yields in the wheat-fallow rotation remained constant, the oat yields in the oat-fallow rotation had declined. The average yearly rate of decline per acre was somewhat over half a bushel of grain at Rutherglen and at Longeronong, and over half a hundredweight of hay at Werribee. The inclusion of a single year of pasture in the rotation caused an upward trend of about one-third of a bushel per acre per year in the wheat yields at Rutherglen.

The method adopted by Forster was employed to determine whether similar trends have occurred in South Australian experiments that have followed constant rotations for a number of years. The experiments studied had been conducted at Booborowie Experimental Farm during 1917-1929 (4), at Roseworthy College during 1905-1928 (2), and at the Waite Institute during 1926-1940 (6).

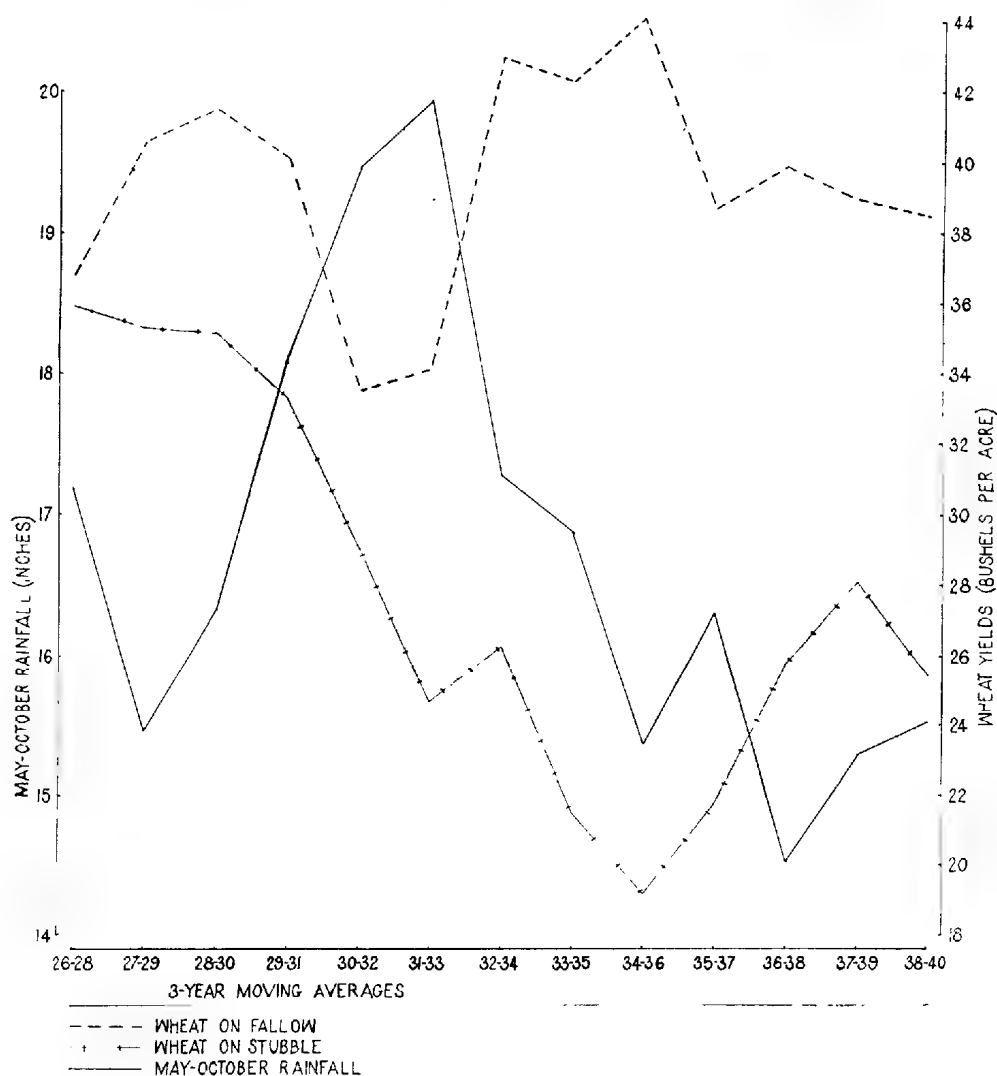


Fig. 2

Comparison of wheat yields at the Waite Institute with May-October rainfall.

In all of these experiments the yields are subject to considerable fluctuations, since they are from a single plot under each treatment during each year. These fluctuations have been overcome to some extent by the use of three-year moving averages, obtained by averaging the years 1905-1907, 1906-1908, etc.; omitting the first year of the period, and including the next year in order, for each new average.

At Booborowie and Roseworthy the crop yields increased with increases in rainfall. This is illustrated in fig. 1, which shows the actual yields of wheat on fallow at Booborowie, together with the May-October rainfall. Yields of oats, barley and peas at the Waite Institute showed a similar relationship to rainfall. Wheat yields in continuously cropped rotations showed no such relationship, whilst the yields of wheat on fallow were lowest in the years of highest rainfall. The relationships between May-October rainfall and the yield of wheat (a) continuously and (b) in the wheat-fallow rotation are shown in fig. 2.

In cases where the yield of the crop was related to the seasonal rainfall, the three-year moving averages were corrected for the variations in seasonal rainfall, the method of partial regression being used. The results obtained from each of the three centres will be considered separately, as the relative importance of the factors that influence yield trends differed from centre to centre.

#### (a) BOOBOROWIE

The average annual rainfall during the period of the experiment, 1917-1929, was 18.9 inches, of which 13.6 inches fell during the period May-October.

The trends in yields of (a) wheat, in the wheat-fallow rotation; (b) oats, in the wheat-oats-fallow rotation; and (c) barley, in the wheat-barley-fallow rotation will be used as the basis for comparison with longer rotations. The mean yields of these crops and the trends in yield are shown in Table 1. The trend in wheat yields on the wheat-fallow rotation is also illustrated in the upper graph of fig. 3.

TABLE 1  
Mean Yields and Yield Trends of Wheat, Oats, and Barley at Booborowie  
(adjusted for May-October Rainfall)

Crop and Rotation	Mean yield (bush./ac.)	Regression co-efficient (bushels per acre per annum)
Wheat in wheat-fallow rotation ....	26.7	+ 0.10
Oats in wheat-oats-fallow rotation ....	26.9	— 1.98 <sup>(1)</sup>
Barley in wheat-barley-fallow rotation ....	16.4	— 1.04 <sup>(1)</sup>
Wheat in wheat-pasture-fallow rotation (no manure)	17.3	— 0.60 <sup>(2)</sup>

While the yield of wheat on fallow remained fairly constant when rainfall effects had been eliminated, the yields of stubble-sown oats and barley declined by two bushels per acre and one bushel per acre respectively, for each year of the experiment. Superphosphate (36%) was applied to the wheat crop at the rate of 2 cwt. per acre, and to the oat and barley crops at the rate of 1 cwt. per acre. Where wheat was grown without fertilizer in the wheat-pasture-fallow rotation, the yield declined by over half a bushel per acre for each year of the experiment.

To determine the effects on the trend in wheat yields, of including oats in the rotation, the yield of wheat in the wheat-fallow rotation was subtracted from the yield of wheat in the wheat-oats-fallow rotation. The yield of wheat in the

<sup>(1)</sup> Significant by "t" test  $p < 0.05$ .

<sup>(2)</sup>  $p < 0.01$ .

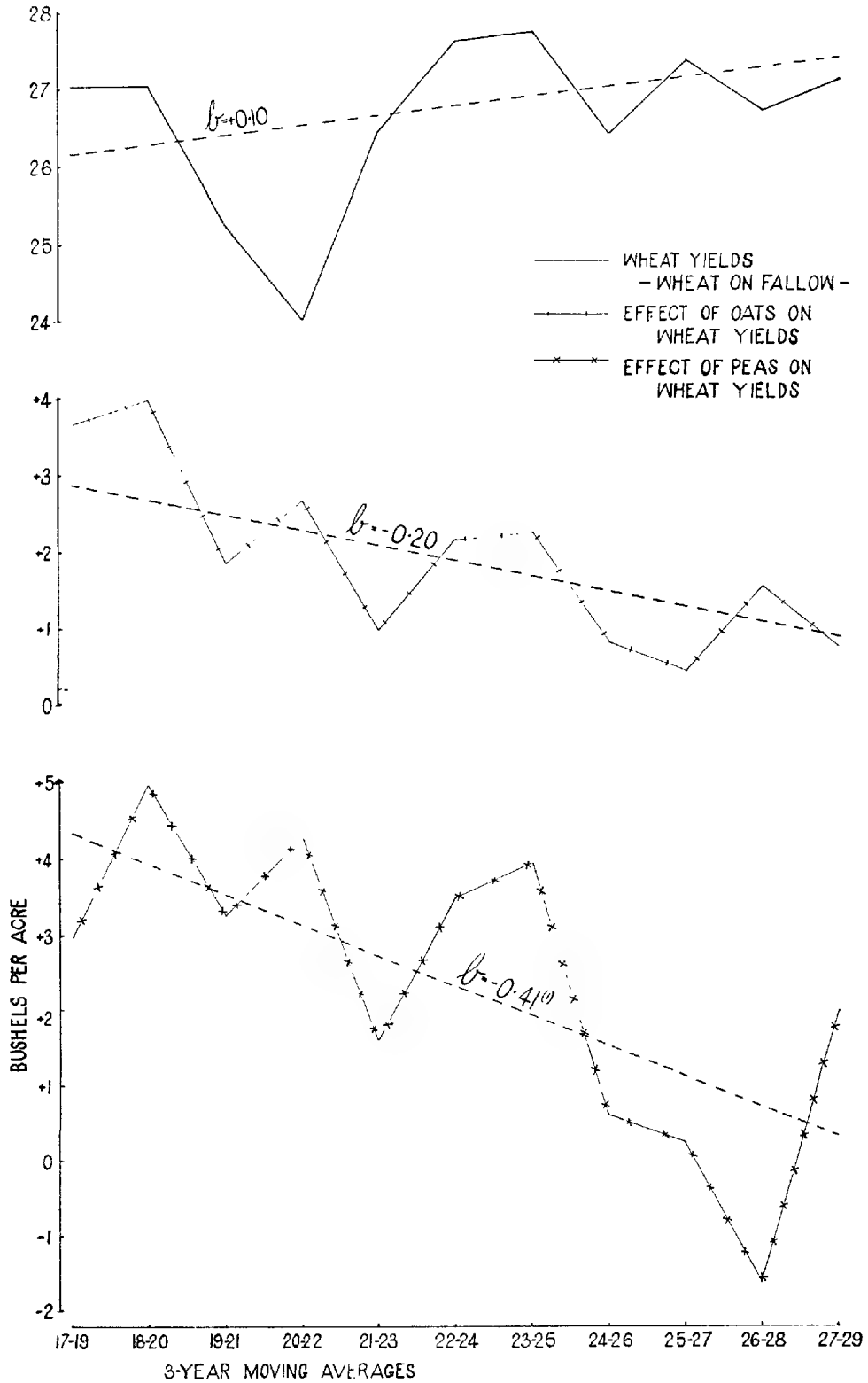


Fig. 3

Yield trend of wheat (wheat-fallow rotation) at Booborowie.  
Effects of inclusion of (a) oats and (b) peas (grazed) on the yield of wheat in the rotation—adjusted for May-October rainfall.

wheat-pasture-fallow rotation was then subtracted from the yield of wheat in the wheat-oats-pasture-fallow rotation. The mean differences were used as an index of the effect of oats on wheat yield for each year. These differences were adjusted for rainfall in the same manner as were the yields of the crops shown in Table 1. The influence of oats and other crops on the trends in wheat yield are shown in Table 2, together with the influence of pasture on oat and barley yields.

TABLE 2

Effects of the inclusion of various Crops on the Yields and Yield Trends of  
(a) Wheat, and (b) Oats and Barley at Booborowie (adjusted for May-October Rainfall)

Crop introduced					Number of comparisons used	Mean increase in yield (bush. per acre)	Regression co-efficient (bushels per acre per annum)
(a) Wheat on fallow							
Oats	....	....	....	....	2	+ 1.9	— 0.20
Barley	....	....	....	....	2	— 1.1	— 0.54 <sup>(2)</sup>
Pasture	....	....	....	....	3	+ 0.8	+ 0.00
Ryegrass (2 years)	....	....	....	....	1	+ 0.3	— 0.04
Lucerne (3 years)	....	....	....	....	1	+ 2.3	— 0.98 <sup>(2)</sup>
Peas (grazed)	....	....	....	....	1	+ 2.3	— 0.41 <sup>(1)</sup>
Rape (grazed)	....	....	....	....	1	+ 0.9	— 0.33 <sup>(2)</sup>
(b) Stubble-sown oats and barley							
(i) Oats							
Pasture	....	....	....	....	1	— 2.2	+ 0.65 <sup>(1)</sup>
(ii) Barley							
Pasture	....	....	....	....	1	+ 1.8	— 0.45

The wheat crops received a dressing of 2 cwt. per acre, and the oats, barley, rape, and peas a dressing of at least 1 cwt. per acre of 36% superphosphate. No fertilizer was applied to the natural pasture, ryegrass, or lucerne.

The inclusion of oats or barley appears to have caused a slight decline in the yield of wheat from year to year. The yields maintained themselves where a natural pasture lasting one year or a two-years ryegrass pasture had been included in the rotation. Where the wheat was followed by three years of grazed lucerne, the yield of wheat decreased at the rate of nearly a bushel per year, compared with the wheat-fallow rotation. This may have been due to the removal of soil phosphates by the unmanured lucerne; or to the depletion of more moisture by the lucerne than was restored during the one year of fallow in five. Moisture depletion may have been a factor in the other rotations in which declining wheat yields occurred. The effects of the inclusion of (a) oats and (b) grazed peas on wheat yields are graphed in fig. 3.

The inclusion of pasture for one year reduced the rate at which oat yields were declining by over half a bushel per acre per year. This was not the case with barley, a possible explanation being that the natural pasture acted as an intermediate host for the take-all fungi, which would tend to increase the incidence of this disease in the barley crop.

The experiment included a series of plots under the wheat-pasture-fallow rotation, in which a range of dressings of superphosphate (36%) were applied to the wheat crop. In Table 1 it was shown that the yield of wheat declined at the rate of over half a bushel per acre per annum where no phosphate was applied, to the wheat in this rotation. The effects of increasing dressings of superphosphate are listed in Table 3. The effect of 2 cwt. per acre, together with the trend in yield of unmanured wheat, is shown in fig. 4.

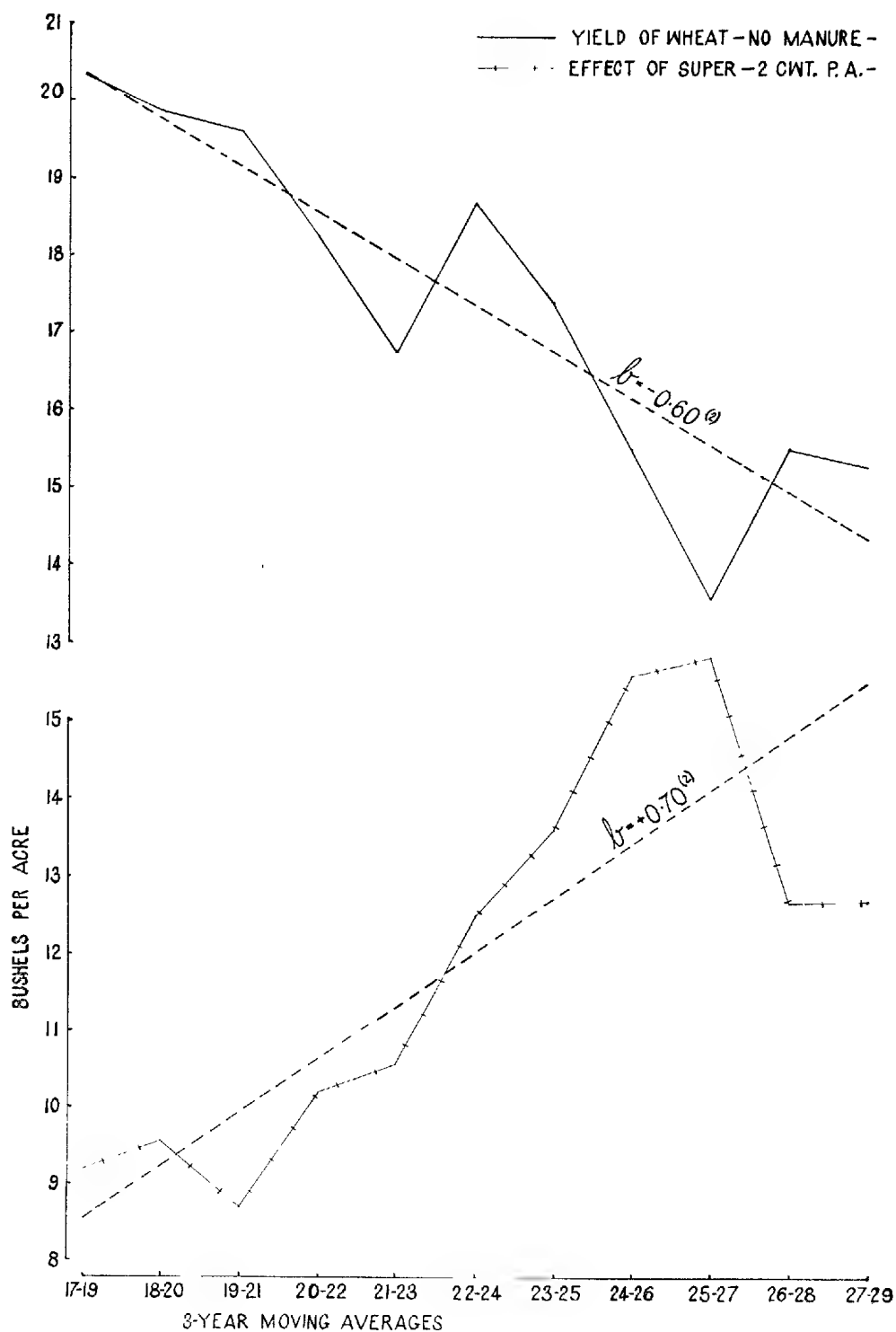


Fig. 4

Wheat pasture-fallow rotation at Booborowie.

(a) Yield trend of wheat—no manure. (b) Effect of 2 cwt of 36% superphosphate per acre on yield trend of wheat—adjusted for May-October rainfall.



TABLE 3

The effect of Superphosphate (36%) on the Yield Trends of Wheat in  
Wheat--Pasture-Fallow Rotation at Booborowie (adjusted for May-October Rainfall)

Rate of application of superphosphate	Mean increase in wheat yield (bushels per acre)	Regression co-efficient (bushels per acre per annum)
$\frac{1}{2}$ cwt. per acre ....	11.9	+ 0.29 <sup>(1)</sup>
1 cwt. per acre ....	12.5	+ 0.58
2 cwt. per acre ....	12.0	+ 0.70 <sup>(2)</sup>
3 cwt. per acre ....	11.5	+ 0.59 <sup>(2)</sup>

The difference between the wheat yields on the manured and unmanured plots increased with time. Where the dressing was 1 cwt or more per acre, the amount of increase per year was about equal to the yearly decline in the yield of the unmanured wheat plot. In other words, the yield level for dressings of 1, 2, and 3 cwt. per acre of 36% superphosphate remained constant with time.

#### (b) ROSEWORTHY

The average annual rainfall during the period under review (1905-1928) was 17.5 inches, of which 14.3 inches fell during the months April-November.

In the rotation experiment the wheat-fallow rotation was continued for twenty-three years and the wheat-sorghum rotation for seventeen years. In addition, the wheat-fallow rotation was continued for twenty-two years in a manurial experiment, in which dressings of (a) 36% superphosphate (2 cwt. per acre), (b) basic slag (2 cwt. per acre), and (c) farmyard manure (14 tons per acre) were applied to the wheat crop.

The yields were corrected for the April-November rainfall, and the trends in yield which are shown in Table 4 were calculated from the three-year moving averages.

TABLE 4

Mean Yields and Trends in Yield of Wheat at Roseworthy  
(adjusted for April-November Rainfall)

Treatment	Mean Yield (bushels per acre)	Regression co-efficient (bushels per acre per annum)
Wheat, fallow (super, 2 cwt. per acre) ....	17.8	— 0.49 <sup>(2)</sup>
Wheat, sorghum (super, 2 cwt. per acre) ....	14.9	— 0.29 <sup>(1)</sup>
Wheat, fallow (no manure) ...	13.2	— 0.58 <sup>(2)</sup>
Wheat, fallow (super (2 cwt. per acre) ....	19.4	— 0.58 <sup>(2)</sup>
Wheat, fallow (basic slag 2 cwt. per acre) ..	17.0	— 0.46 <sup>(2)</sup>
Wheat, fallow (farmyard manure, 14 tons per acre)	15.7	— 0.54 <sup>(2)</sup>

The yield of wheat in the wheat-fallow rotation declined by about half a bushel per acre per year, irrespective of the manurial treatment. The decline in yield was somewhat less under the wheat-sorghum rotation, in which the sorghum was grazed.

#### (c) WAITE INSTITUTE

The average rainfall during the period concerned (1926-1940) was 23.9 inches per annum.

The yields were corrected for rainfall as follows:

Wheat on stubble	-	May-October rainfall
Wheat on fallow	-	no correlation with rainfall
Oats	- - -	May-October rainfall
Barley	- - -	effective rainfall (5), falling between break of season and beginning of summer dry period
Peas	- - -	total rainfall

These were the rainfall periods most closely associated with the yields in each case.

Three-year moving averages were used to determine the trends which are shown in Table 5.

TABLE 5  
Mean Yields and Trends in the Yield of Wheat, Oats, Barley, and Peas at the Waite Institute

Crop and rotation	Mean yield (bushels per acre)	Regression co-efficient (bushels per acre per annum)
Wheat continuously - - - -	15.3	- 1.35
Wheat in wheat-fallow rotation - -	34.1	- 0.36
Oats in wheat-oats-fallow rotation -	46.9	- 3.40 <sup>(2)</sup>
Barley (mean of 2 rotations) - -	46.6	- 2.19 <sup>(2)</sup>
Peas (mean of 4 rotations) - - -	25.3	+ 0.17

All the sown crops received a dressing of 2 cwt. per acre of 45% super-phosphate.

As at Booborowie, no significant decline occurred in the yield of wheat, but stubble-sown oats and barley decreased in yield during the course of the experiment (1926-1940). For example, the unadjusted oat yield (mean of two plots) varied from 68 bushels in 1926 to 15 bushels in 1935, but has since increased to 30 bushels in 1940. This latter increase may have been due to hand weeding.

The influence of other crops on the yield of wheat and oats is shown in Table 6.

TABLE 6  
Effects of the inclusion of other Crops on the Mean Yields and Yield Trends of Wheat and Oats at the Waite Institute

	Number of comparisons	Mean increase in yield (bushels per acre)	Regression co-efficient (bushels per acre per annum)
(a) Wheat on continuously cropped land			
Effect of peas - - - -	1	11.2	+ 0.08
Effect of oats } Rotations	1	3.6	+ 0.18
Effect of barley } include peas	1	6.0	+ 0.40 <sup>(2)</sup>
(b) Wheat after fallow			
Effect of peas - - - -	1	5.6	+ 0.90 <sup>(2)</sup>
Effect of oats - - - -	1	2.9	+ 0.35
Effect of barley - - - -	1	5.0	+ 0.69 <sup>(2)</sup>
Effect of ryegrass - - - -	2	6.3	+ 0.62 <sup>(2)</sup>
(c) Oats on stubble			
Effect of ryegrass - - - -	1	10.4	+ 2.06 <sup>(2)</sup>

The ryegrass was treated as a hay crop in the early years of the experiment, but since 1938 it has been grazed.

The inclusion of barley appears to have checked the decline in yield of wheat on continuously cropped land. It must be remembered that the comparison is between the wheat-barley-peas rotation and the wheat-peas rotation. The effect of barley in a rotation without a legume may have been quite different. Peas, oats, or barley, in the rotation at the Waite Institute have maintained or increased the yield of wheat on fallow, whereas at Booborowie, oats or barley in the rotation caused the wheat yields to decline with time. These results at the Waite Institute, together with the negative correlation between the yields of wheat on fallow and seasonal rainfall, suggest that a fallow every second year conserves too much moisture under Waite Institute conditions.

That the fertility of the soil is declining under these rotations is shown by the fact that the yields of stubble-sown oats and barley have decreased rapidly.

As the yield of peas has not declined, the loss of fertility appears to have been largely due to the exhaustion of available supplies of nitrogen. Stubble-sown cereals at the Waite Institute are known to respond to nitrogenous fertilizers, and soil nitrates accumulate during fallow periods (6).

A single year of ryegrass maintained the yield of wheat on fallow and checked the rate of decline in yield of oats on stubble.

#### DISCUSSION

At Roseworthy, though at neither of the other centres, the yield of wheat declined under the wheat-fallow rotation. This decline occurred under the only four manurial treatments included.

At Booborowie and the Waite Institute, the yields of stubble-sown oats and barley declined at a significant rate even though the dressings of superphosphate seem adequate. The introduction of a year of natural pasture at Booborowie, or of a year of ryegrass at the Waite Institute, decreased the rate at which the yield of oats or stubble declined. The take-all factor probably prevented natural pasture having a similar effect on the trend of barley yields at Booborowie, the only centre at which two host plants for the take-all preceded a year of pasture.

The declining fertility, as evidenced by the gradually decreasing yields of stubble-sown cereals, appears to be linked with the depletion of soil organic matter and available nitrogen on land under a rotation of the wheat-oats-fallow type. Stubble-sown crops respond to inorganic nitrogenous fertilizers at the Waite Institute, suggesting that the nitrogen supply is an important factor in the growth of these crops on soil adequately supplied with phosphate.

A single year of natural pasture at Booborowie or of ryegrass at the Waite Institute reduced the rate at which oat yields declined, suggesting that these crops restored some organic matter to the soil. Wood (7), working with Waite Institute soil, showed the mineralizable nitrogen to be much higher after a grazed pea crop, even where the latter had been grazed. Thus the introduction of grazed leguminous crops or of pastures rich in trefoils or clovers might further reduce the rate of nitrogen depletion and thus tend to overcome the decline in crop yields. A study of rotations in which stubble-sown crops are followed by pasture or grazed legumes would be necessary to determine the extent to which fertility could be maintained by these practices.

The inclusion, at Booborowie for three years, of a lucerne pasture caused a downward trend in the yield of wheat. Two factors may have been responsible for this decline, namely, the depletion of soil moisture reserves and the uptake of soil phosphate by the lucerne plant—the land having received no fertilizer while under lucerne.

The effect of dwindling phosphate supply was demonstrated at Booborowie; yields of wheat in the wheat-pasture-fallow rotation declining on land that had received no fertilizer. It would be interesting to know whether the yield of wheat would decline in a rotation containing lucerne top-dressed with superphosphate.

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# **ADDITIONS TO THE ACARINA-PARASITOIDEA OF AUSTRALIA PART I**

By H. WOMERSLEY, F.R.E.S., A.L.S., South Australian Museum

## **Summary**

Hitherto only a few species of Acarina have been recorded from Australia as belonging to the family Parasitidae (Gamasidae) in the wide sense of Vitzthum (Handbuch der 2001. 1931).

# ADDITIONS TO THE ACARINA—PARASITOIDEA OF AUSTRALIA

## PART I

By H. WOMERSLEY, F.R.E.S., A.L.S., South Australian Museum

[Read 13 August 1942]

### INTRODUCTION

Hitherto only a few species of Acarina have been recorded from Australia as belonging to the family Parasitidae (Gamasiidae) in the wide sense of Vitzthum (Handbuch der Zool. 1931).

In his "A Synopsis of Australian Acarina," Rec. Aust. Museum, 1916, 6, (3), 173, Rainbow only lists one species, *Gamasus flavolimbatus* L. Koch, Verhandl. K. Zool. Ges., Wien, 1867, from Queensland, which might belong to this family. Unfortunately the original publication is not available to me, and as the species has not been recorded since, I am as yet unable to express any opinion as to its status.

In Trans. Roy. Soc. S. Aust., 1916, 40, Banks described a number of Acari from ants' nests in Tasmania, collected by A. M. Lea, amongst which were three species referred to the genus *Parasitus* Latreille. These were *P. lyratus*, *P. disparatus* and *P. inversus*. Of these species there are, in the South Australian Museum collections, mounted specimens labelled in Lea's handwriting as the first two species and therefore presumably mounted by him on their return from Banks. It has now been possible to remount these specimens for more critical examination with following results.

*Parasitus lyratus*, two females, although agreeing with Banks' description and figures in general are yet inaccurately drawn in many important details; they are not a *Parasitus* but belong to the genus *Hypoaspis*, of the Laelaptidae. *Parasitus disparatus*, six females, five of which do not agree with Banks' description and figures of this species, but do agree with those of *Parasitus inversus*, specimens of which, according to Lea's notes, were not returned to the South Australian Museum. They are also not a Parasitid but another species of *Hypoaspis*. The sixth specimen, however, may be *disparatus* insofar as it has clavate dorsal setae as figured by Banks, but the configuration of its ventral shields is again that of the genus *Hypoaspis*.

The species described by Banks 1916 as *Cyrtolaclaps femoralis* on re-examination of the material in the South Australian Museum and comparison with fresh material, proves to be a *Gamasiphis*.

In the present paper, the families as defined by Oudemans 1939 have been adopted and species belonging to the Parasitidae, Neoparasitidae, Gamasolaelaptidae, Pachylaelaptidae and Macrochelidae are recorded from Australia as follows:

### Parasitidae

*Parasitus americanus* Berl. 1888.

*Pergamasus crassipes* Latr. 1746 v. *australicus* nov.

" " v. *longicornis* Berl. 1906

" ? *barbarus* Berl. 1905

## Neoparasitidae—

- Hydrogamasus dentatus* n. sp.  
 „ *relatus* n. sp.  
 „ *relictus* n. sp.  
 „ „ v. *major* n. v.  
 „ *australicus* n. sp.  
*Gamasiphis femoralis* (Banks 1916)  
*Austrogamasus gracilipes* (Banks 1916).

## Gamasaolaelaptidae—

- ? *Digamasellus concina* n. sp.  
 ? „ *punctatus* n. sp.  
 ? „ *trägärdhi* n. sp.

## Pachylaelaptidae—

- Pachylaelaps australicus* n. sp.

## Macrochelidae—

- Macrocheles vagabundus* Berl. v. *australis* Berl. 1918  
 „ *coprophila* n. sp.  
*Nothrholaspis* ? *montivagus* Berl. 1887  
*Geholaspis* sp.  
*Eucpicrius filamentosus* n. g., n. sp.

## Family PARASITIDAE Oudemans 1902

Tijdschrift v. Entom. 1902, 45, 6.

Female epigynial shield triangular with a pointed, anteriorly directed apex, strongly chitinised, posterior margin straight or almost so, usually with a single pair of setae; sternal shield with three pairs of setae and consisting of the coalesced jugular and coxal shields; metasternal shield usually present and free; prae-endopodal shields free. Ventral and anal shields coalesced and, sometimes, partially so with the dorsal. Fork of palpal tarsus three-pronged.

Oudemans (Zool. Anz., 126, 21, 1939) refers to this family only the genera *Amblygamasus* Berl. 1903, *Eugamasus* 1892, *Holoparasitus* Ouds. 1936 (= *Ologamasus* Berl. 1906 non 1888), *Parasitus* Latr. 1795 (= *Carpais* Latr. 1796 = *Gamasus* Latr. 1802), *Pergamasus* Berl. 1903, *Sessiluncus* G. Can 1898 and *Trachygamasus* Berl. 1906.

These genera may be separated by the following key.

## KEY TO THE GENERA OF PARASITIDAE

- |   |  |  |   |
|---|--|--|---|
| 1 | Claws of leg I sessile. Dorsal shield entire.  | Gen. <i>Sessiluncus</i> G. Can. 1898   | 2 |
|   | Claws of all legs pedunculate.   |  |   |
| 2 | Metasternal shields wanting or ? fused with sternal shield. Claws of leg I on a long 2-segmented peduncle. Dorsal shield divided by a fine suture. | Gen. <i>Trachygamasus</i> Berl. 1906   |   |
|   | Metasternal shields distinct and separated from sternal shield. All claws on a simple peduncle.  |  | 3 |
| 3 | Dorsal shield divided into two.  |  | 4 |
|   | Dorsal shield entire.  |  | 5 |
| 4 | Labial cornicles of ♂ with distinct basal segment.   | Gen. <i>Parasitus</i> Latr. 1795   |   |
|   | Labial cornicles of ♂ sessile, without basal segment.  | Gen. <i>Eugamasus</i> Berl. 1892   |   |
| 5 | Ventrianal shield posteriorly coalesced with dorsal.   | Gen. <i>Holoparasitus</i> Oudms. 1936<br>(= <i>Ologamasus</i> Berl. 1906 non 1888) |   |
|   | Ventrianal shield entire, free from dorsal.  |  | 6 |
| 6 | Leg II with practically unarmed femur; processes on genu and tibia backwardly directed.  | Gen. <i>Amblygamasus</i> Berl. 1903  |   |
|   | Leg II with strong femoral processes directed forwards.  | Gen. <i>Pergamasus</i> Berl. 1903  |   |

## Genus PARASITUS Latr. 1795

Mag. encyclop., 3, (13), 19.

= *Gamasus* Latr. 1802 *Sonnini's Buffon Ins.*, 3, 64.

Shape a more or less elongate oval. Dorsal shield in both sexes divided by a line or narrow suture, well chitinised. Femur of leg II of male with a strongly developed calcar and a small axillary tubercle, genu and tibia also with processes. Movable chela of mandibles with a more or less fused calcar process. Labial cornicles with a distinct basal segment. Epistome three- or five-spined. Deutonymph with the dorsal shields well separated, posterior subtriangular. In female, prae-endopodal and metasternal shields separated, latter large and distinct. Claws on all legs on long simple peduncles.

## PARASITUS AMERICANUS Berlese 1888

*Gamasus americanus* Berl. 1888, *Acari austro-americi* estr., 23; 1906, *Redia*, 3, fasc. 2, 138, tab. II, fig. 7, X, fig. 6, XV, fig. 2, 14.

(Fig 1, A-K)

*Adult*—Length to 1,000  $\mu$  (Berlese 1,120  $\mu$ ), width 650  $\mu$ . Colour brownish-yellow with very fine mottling of brown spots. Shape elliptical oval, with slight shoulders. Dorsal shield covering the whole body, divided into two by a suture. Dorsal chaetotaxy as in fig. 1, A, the large scapular setae to 150  $\mu$  long and blunt-tipped, the longer dorsal blunt setae to 78  $\mu$ , the finer pointed setae to 65  $\mu$ .

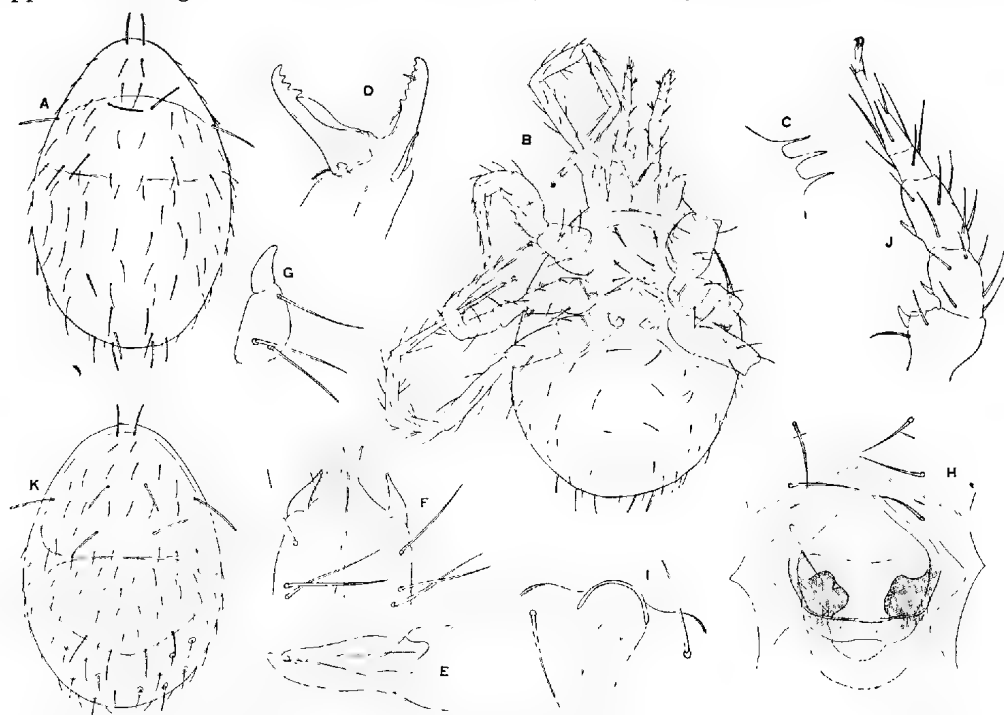


Fig 1, A-K *Parasitus americanus* Berl.: A, dorsum ♀; B, venter ♀; C, epistome ♀; D, mandible ♀; E, same ♂; F, labial cornicles ♀; G, labial cornicle ♂; H, epigyne ♀; I, genital foramen ♂; J, leg II ♂; K, deutonymph, dorsal.

Mandibles as figured, ♀ movable chela with four strong teeth in distal half, fixed chela with 7-9 smaller teeth; ♂ movable chela with the calcar process fused, apically with two blunt rounded teeth at the apex, fixed chela without distinct teeth. Epistome trispinous as in fig. 1 C, usually with the median prong bluntly

pointed but often apically truncate as figured by Berlese. Labial cornicles in ♂ with distinct basal segment.

Legs—♀, I and IV long and slender, 1,160  $\mu$  and 1,250  $\mu$  respectively, II and III shorter and thicker, 660  $\mu$  and 750  $\mu$  respectively, all legs unarmed; ♂, I and IV 1,085  $\mu$  and 1,170  $\mu$  respectively, II and III 750  $\mu$  and 780  $\mu$  respectively; leg II armed with processes as in fig. 1, J; jugular shields fused with the sternal shield. Peritreme long and slender. Genital opening of ♂ under the front edge of sternal shield; of ♀ as figured (fig. 1, H), epigynium apparently without setae; endogynium internally unarmed, posteriorly with a single transverse row of long fibrils. Anus small, posterior-ventral.

*Deutonymph*—Dorsally, as figured (fig. 1, K). Length 920  $\mu$ , width 580  $\mu$ . With anterior and posterior shields, posterior shield short, 335  $\mu$  long. Posterior of the second dorsal shield are twelve small ovoid platelets from which arise single setae, 52  $\mu$  long. Otherwise as in adult without sexual characters.

*Loc.*—A very common species occurring in manure and on cultivated ground, etc. Western Australia: Perth, August 1931 (H. W.), adult and nymph. South Australia: Glen Osmond, March 1933, August 1934; Mount Barker, June 1934; Long Gully, August 1938; Adelaide, July 1942.

*Remarks*—Originally described by Berlese from Paraguay, from female and nymph only, this species is probably almost cosmopolitan in agricultural areas.

#### Genus PERGAMASUS Berlese 1906

= *Gamasus* ex. p. auct., subgen. *Gamasus* ex. p. Berlese. Mesostigmata.  
*Pergamasus* Berl, 1906, Redia, 3, fasc. 1.

Parasitidae with the epigynial shield triangular and separated from the fused ventrianal shield; metasternal and parasternal shields well developed, former with one pair of hairs and one pair of pores. Prae-endopodal shields well developed and distinctly separated from the sternal shield. Jugular shields coalesced with sternal. Sternal shield with three pairs of setae and two pairs of pores. Endogynium various, armed or not with teeth, pockets and median process.

Legs generally long, especially I and IV, and all with long caruncle and a pair of claws; leg II of male on femur armed with prominent blunt processes.

Cuticle of shields with scale-like reticulations.

#### PERGAMASUS CRASSIPES (L.) Latr.

*Acarus crassipes* L. 1746, Fauna Suec. 1969, *idem* 1735, Syst. nat., Ed. 1.

Hermann 1804, Mem. Apt., tab. 3, fig. 6.

*Acarus testudinarius* Hermann 1804, Mem. Apt., tab. 9, fig. 1.

*Gamasus quinquespinosus* Kramer 1876, Gamasiden.

*Gamasus (Pergamasus) crassipes* Berl. 1884, A.M.S. it. Rept., fasc. 13, fig. 7, 8; 1906, Redia, 3, fasc. 1, 229 tab. V, fig. 11, 18, VIII 9, XIII 5, XVII 7.

#### var. *australicus* nov.

(Fig. 2, A-E)

*Female*—As in the typical form but differing in the detailed structure of the endogynium. Colour dark brownish-yellow. Length 1,170  $\mu$ , width 670  $\mu$ . Dorsal and ventral setae long, fine and pointed. Mandibles as in fig. 2 E. Epistome (fig. 2 B) five-spined, the median the longest and tapering rather suddenly for the posterior fourth. Palpi as in fig. 2 C. Endogynium with two large pockets with a median bifid process which sometimes appears asymmetrical or even simple; anterior walls of vagina with denticles. Epigynial shield with concave sides, so that it perceptibly narrows before the halfway.



*Loc.*—South Australia: Mount Barker, 24 June 1934, two spec. (H. W.); Glen Osmond, May 1935, one spec. (R. V. S.); National Park, Belair, January 1938 one spec., (H. W.).

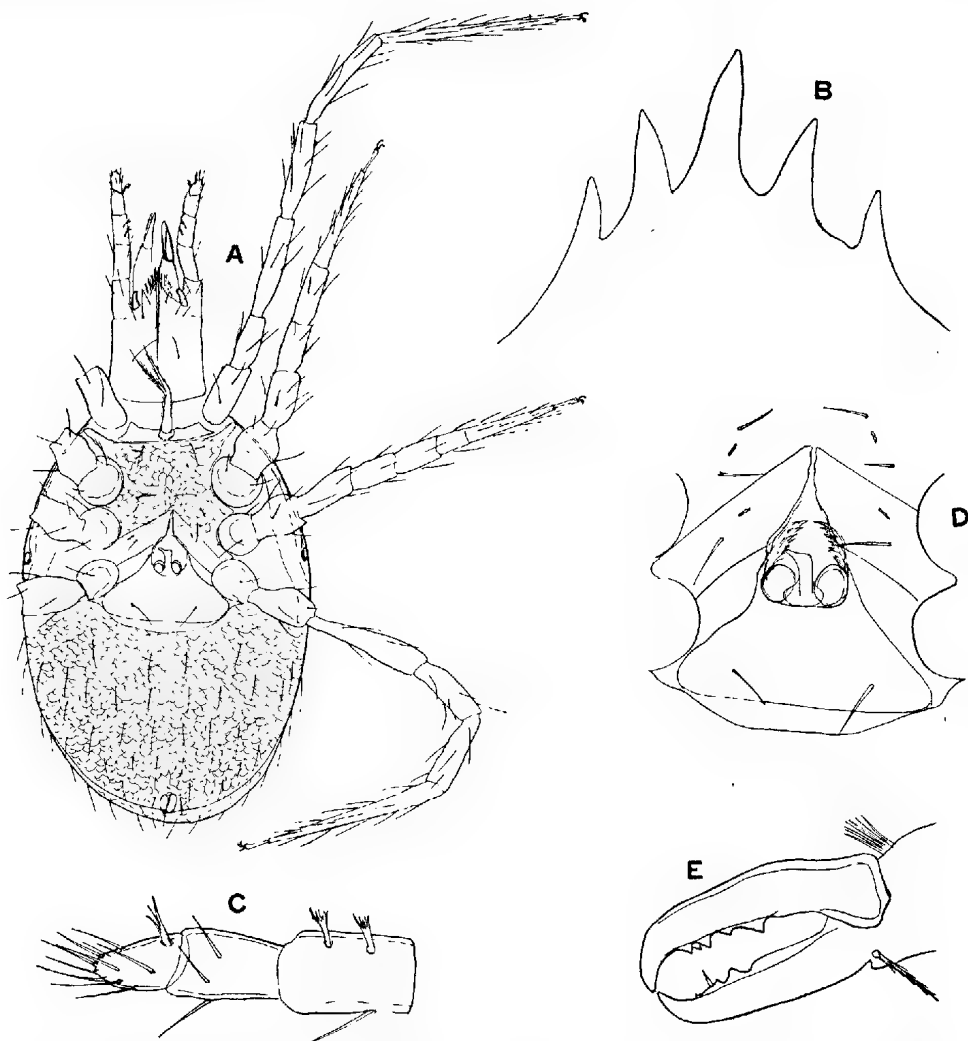


Fig. 2, A-E *Pergamasus crassipes* v. *australicus* n.v.: A, venter ♀; B, epistome ♀; C, tip of palp; D, epigyne and metasternal shields; E, mandible ♀.

*Remarks*—In the absence of males, the above specimens are referred with some uncertainty to a variety of the European *P. crassipes*, for Berlese gives several species with somewhat similar epigynial structures and epistomes. From the typical form it differs in the teeth on the wall of the vagina.

var. *LONGICORNIS* Berlese 1906

Redia, 3, fasc 1, 232.

(Fig. 3, A-I)

Length 1,670  $\mu$ , width 100  $\mu$ . Legs: ♀, I 2,170  $\mu$ , II 1,400  $\mu$ , III 1,420  $\mu$ , IV 2,100  $\mu$ ; ♂, I 1,420  $\mu$ , II 900  $\mu$ , III 1,000  $\mu$ , IV 1,420  $\mu$ . Leg II of male with pronounced processes on femur and tibia as in fig. 3 H-I. Endogynium without pockets or teeth on vaginal wall but with a pair of blunt lobes. Epistoma with five short equal teeth.

*Loc.*—One male and one female from Hobart, Tasmania, July 1937 (J. W. E.) ; one female, Mount Gambier, South Australia, January 1941 (H. W.).

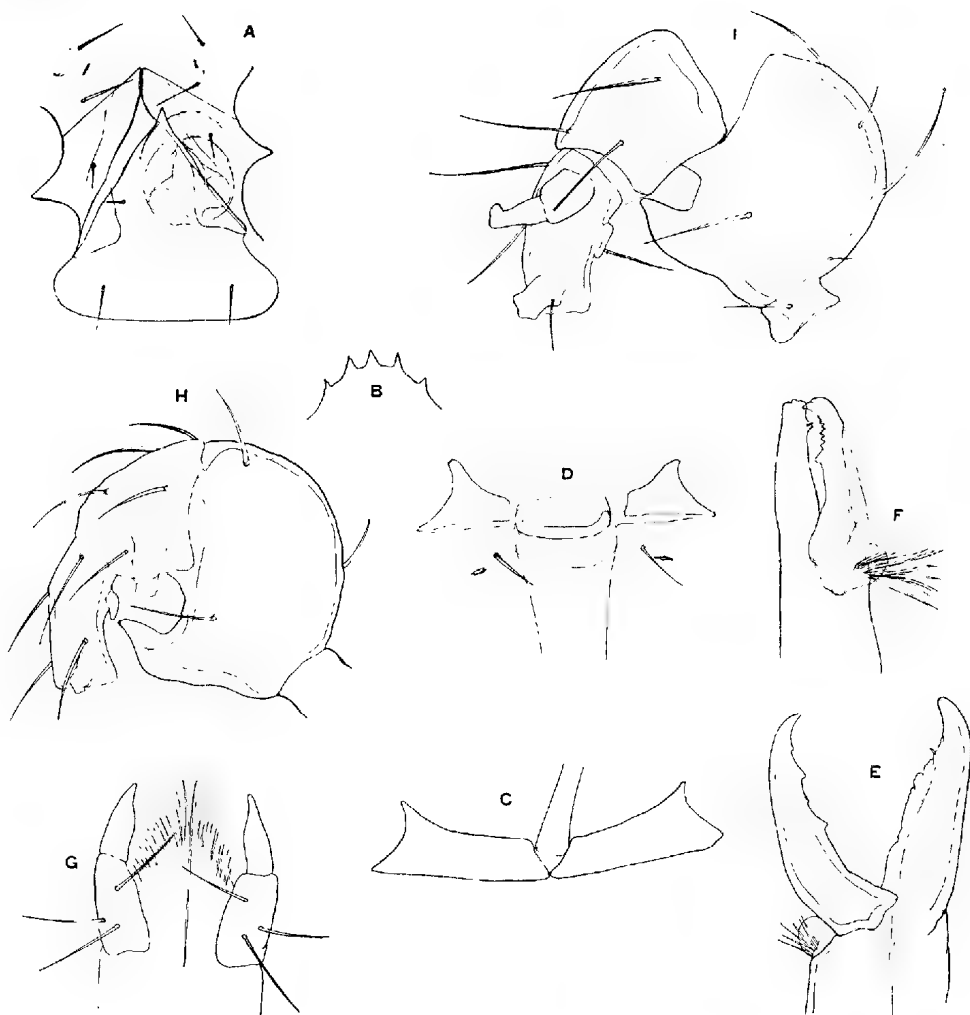


Fig. 3, A-I *Pergamasus crassipes* v. *longicornis* Berl.: A, epigyne and metasternal shields ♀ ; B, epistome ♀ ; C, prae-endopodal shields ♀ ; D, prae-endopodal shields and genital foramen ♂ ; E, mandible ♀ ; F, same ♂ ; G, labial cornicles ♂ ; H-I, leg II ♂ .

*Remarks*—These specimens agree with Berlese's figure of the second leg of the male and in the endogynium with the figure given by Trägårdh (Entom. Tidskft. 3-4, 1938, 149).

PERGAMASUS ? BARBARUS Berlese

Acari nuovi Mater. pel. Manip., V, 1905; Redia, 1908, 2, fasc. 2, 233, 1905, 3, fasc. 1, 2, 5, tab. XV, fig. 1, 9.

(Fig. 4, A-C)

Large, brownish-yellow, well chitinised. Length 1,420  $\mu$ , width 920  $\mu$ . Legs I 1,420  $\mu$  II 920  $\mu$ , III 925  $\mu$ , IV 1,150  $\mu$ . Dorsal setae fine and to 80  $\mu$  in length. The dorsal and ventral shields with fine reticulations. Epistome with five spines, the median of which is but little longer than the others (fig. 4 B). Prae-endopodal

shields as in fig. 4 A with almost parallel anterior and posterior margins. Sternal shield with three pairs of setae. Metasternal shields distinct with the usual pair of setae. Epigynial shield as in fig. 4 C. Endogynium with a pair of pockets with a short bifid process between. Vagina without any armature.

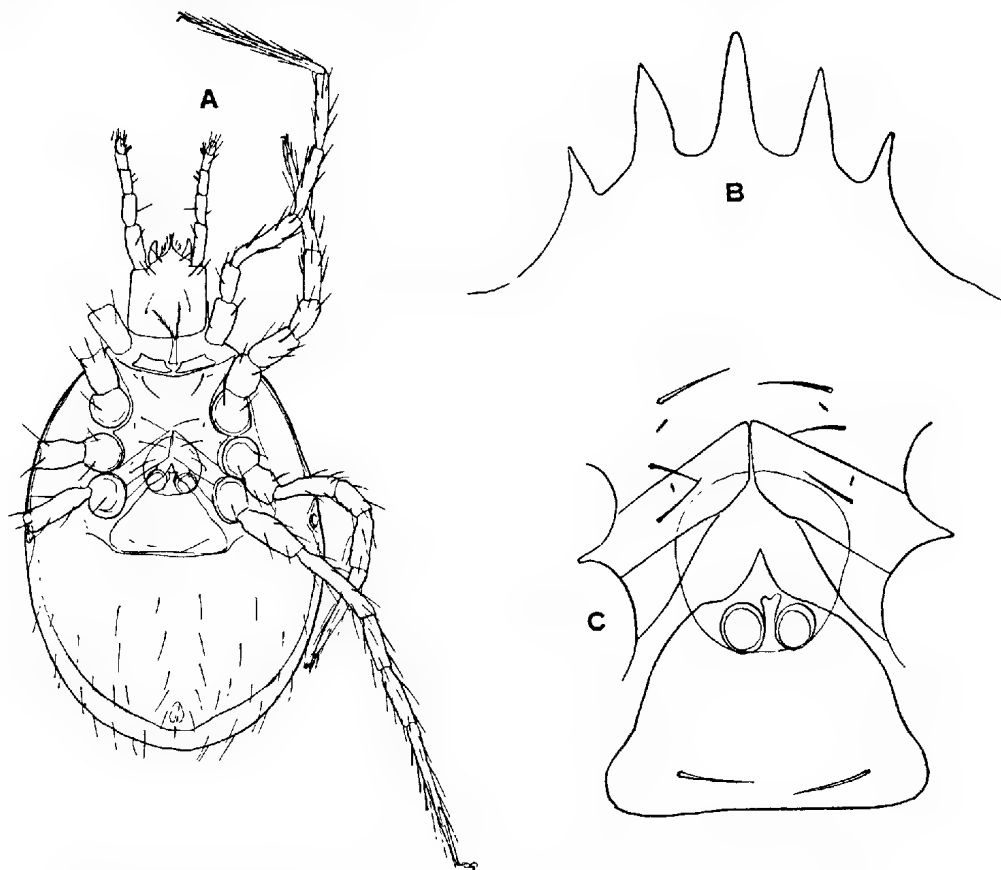


Fig. 4, A-C *Pergamasus* ? *barbarus* Berl.: A, venter ♀; B, epistome ♀; C, epigyne and metasternal shields ♀.

*Loc.*—A single female from moss, National Park, South Australia, January 1938 (H. W.).

*Remarks*—This specimen is referred to Berlese's species from Europe, mainly on comparison of the epigynium and epistome, as figured in his monograph of the genus "*Gamasus*" in Redia 1905.

#### Family NEOPARASITIDAE Oudemans 1939

Zool. Anz. 1939, 126, (1-2), 21.

Fork of palpal tarsus three-pronged. Dorsal shield entire. Epigynium not triangular and not with anterior pointed apex, but gradually or suddenly extending into a membraneous edge which reaches the sternal or metasternal shields, posterior margin variously shaped.

In this family Oudemans (*loc. cit.*) includes the genera *Beaurieuia* Ouds. 1929, *Epicriopsis* Berl. 1916, *Gamasiphis* Berl. 1904, *Hydrogamasus* Berl. 1892, *Megaliphis* Willm. 1937, *Neoparasitus* Oudms. 1901, *Ologamasus* Berl. 1888 (= *Ologamasellus* Berl. 1914), *Poecilochirus* G. and R. Can. 1882 and *Sphaero-*  
*seius*.

Genus *HYDROGAMASUS* Berlese 1892

A.M.S. it. Rept., fasc. 68, fig. 5 (type *Gamasus littoralis* G. & R. Can. 1885 = *G. salinus* Laboulbène 1851).

Neoparasitidae with the dorsal shield entire in adults of both sexes. Ventral, in ♀ the sternal shield has four pairs of setae, *i.e.*, it consists of the coalesced jugular, coxal and metasternal shields, and is also fused with the first, second and third endopodal shields; the prae-endopodal and fourth endopodal shields are free; epigynium free from the sternal and fused ventrianal shields, with one pair of setae and rounded anterior margin: in ♂ the sternal shield has five pairs of setae and is separated by a suture line from the ventrianal; the prae-endopodal shields are free, the jugular, first, second and third endopodal and metasternal fused with it; the ventrianal shield fused with the dorsal shield; the genital orifice is under the anterior margin of the sternal shield. Epistome triangular with a mucronal apex or with a single long median mucro. Mandibles in ♂ with a free, slender or stouter process on the movable chelae. All legs with caruncle and claws, leg II of male thicker than the others and with process on the femur, and sometimes on genu, tibia or tarsus.

*Hydrogamasus dentatus* n. sp.

(Fig. 5, A-O)

*Female*—Length 750  $\mu$ , width 420  $\mu$ . Dorsal shield strongly chitinated with fine reticulations which posteriorly resemble scaling; dorsal setae fine, anteriorly 65  $\mu$  long, increasing to 110  $\mu$  posteriorly. Epistoma as in fig. 5 B, with a median mucro somewhat longer than depth of base and apically tridentate with the median tooth about one-fourth the length of mucro, base with sides almost straight at 45° and with 6-8 fine short teeth. Mandibles as in fig. 5 G; movable chela with three inner teeth, fixed chela with five teeth, two small ones after the fairly long "pilus dentarius" and three stronger ones before it. Labial cornicles as in fig. 5 I. Palpi as in fig. 5 D, the second segment with a strong ciliated seta and third segment with a spatulate sensory seta as well as a ciliated seta which is somewhat longer than the one on the previous segment, remaining setae simple; sensory fork on tarsus three-pronged, the inner prong shorter than the others. The prae-endopodal shields as in fig. 5 H, with the inner end acutely angular, anterior margins almost straight and outwardly diverging. Sternal shield reaching to posterior edge of coxae III, the apex of the anterior arms split off by a suture (fig. 5 H); the first and fourth pairs of setae corresponding to the fused jugularia and metasternalia are much finer than the second and third pairs. Epigynial shield separated from the sternal and ventrianal, with the pair of setae situated in the postero-lateral angles. Ventral and anal plates fused, large, with the anterior margin almost straight and extending to the outer margins of coxae IV, lateral and posterior margins rounded (fig. 5 A), with 12 fine setae in addition to the two adanal and one postanal setae. Between the anterior margin of the ventrianal plate and coxae IV are two pairs of minute inguinal plates, one at the extreme outer corner of the ventral plate, the other close in to the postero-lateral corners of the genital plate. Legs: I 750  $\mu$ , II 400  $\mu$ , III 500  $\mu$ , IV 750  $\mu$ ; II stouter than the rest; claws small and caruncle short; trochanter of IV with a long anterior process on posterior edge, and a short one on anterior edge; trochanter III without such processes (fig. 5 K); tarsi about eight times longer than wide at the base.

*Male*—Dimensions as in female. Epistome, prae-endopodal and dorsal shields as in female. Ventrianal shield fused with the dorsal shield. Sternal shield with five pairs of setae, all of which are rather short, fine and uniform. Mandibles as in fig. 5-F, movable chela with a single large median tooth and strong stout curved

calcar process which is only fused basally and reaches almost to tip of chela; fixed chela with three teeth, the basal one very blunt and flattened. Palpi as in female, but second segment on the inner apical angle with a stout pitted sensory peg. Labial cornicles pedunculate, not sessile as in female. Legs: II much stouter than the rest; femur with a stout apophysis and a small axillary tubule, genu inwardly with a short flat process, tibia on inside with a stout forwardly directed spine like process. Trochanter IV as in female.

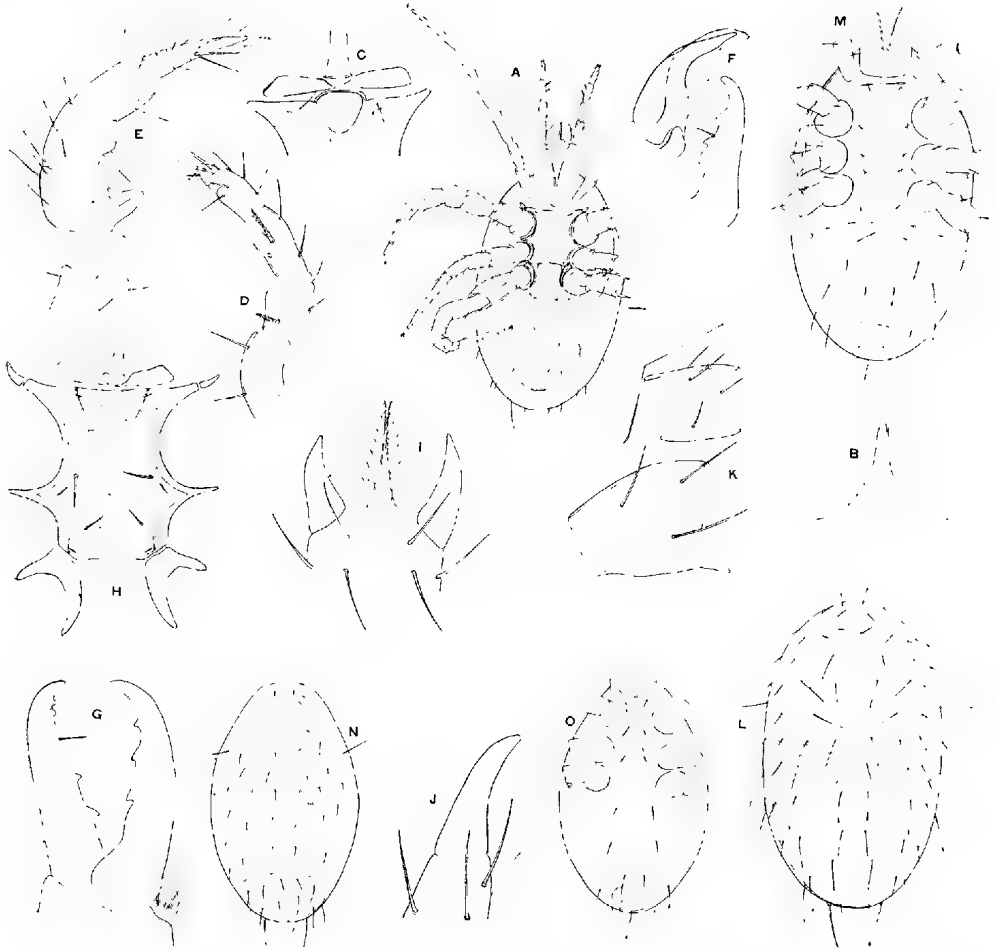


Fig. 5. A-O *Hydrogamasus dentatus* n. sp.: A, venter ♀; B, epistome ♀; C, prae-endopodal shields and ♂ genital foramen; D, palp ♂; E, leg II ♂; F, male mandible; G, same ♀; H, prae endopodal and sternal shields ♀; I, labial cornicles ♀; J, same ♂; K, trochanters III and IV ♀; L, deutonymph, dorsal; M, same ventral; N, protonymph, dorsal; O, same, ventral.

*Deutonymph*—Length 105  $\mu$ , width 58  $\mu$ . Dorsally with two plates as in fig. 5 L. Ventrally (fig. 5 M) with the prae-endopodal shields only just indicated, sternal plate reaching to just past coxae IV, slightly tapering to coxae III, thence more abruptly, with four pairs of setae. Behind coxae IV lies a transverse row of eight small plates, the extreme ones being roughly triangular, the others elongate and narrow. Anal plate small, wider than long. There are 12 setae on the venter, with another pair between the coxae IV and the apex of the sternal plate. Peritreme only reaching to coxae II.

*Protonymph*—Length  $65\ \mu$ , width  $39\ \mu$ . Dorsal plates two as in fig. 5 N, widely separated, with two pairs of small accessory plates in between. Ventrally (fig. 5 O) sternal plate with three pairs of hairs. Anal plate smaller than in deutonymph. Venter with only eight hairs.

*Loc.*—Common in moss from the Mount Lofty Ranges, Belair, Long Gully, Waterfall Gully, South Australia in August and September 1938. Also one specimen from moss from Brisbane, October 1934.

### ***Hydrogamasus relatus* n. sp.**

(Fig. 6, A-M)

*Female*—Length  $670\ \mu$ , width  $335\ \mu$ . Dorsal shield strongly chitinised with fine reticulate lines; dorsal setae fine, uniformly  $40\ \mu$  long. Epistome as in fig. 6 G, H, with a simple median mucro, sides of base almost horizontal, with some fine teeth. Mandibles (fig. 6 B): movable chela with three teeth, fixed chela with four teeth. Labial cornicles sessile (fig. 6, E). Palpi as in *H. dentatus*. Prae-endopodal shields as in fig. 6 M. Sternal shield as in fig. 6 M, the second and third pairs of setae longer and stronger than the first and fourth pairs (apical portion of anterior lobes, and fourth endopodal shield not shown). Legs: I  $580\ \mu$  long, II  $420\ \mu$ , III  $420\ \mu$ , IV  $500\ \mu$ ; II and IV somewhat thicker than I and III;

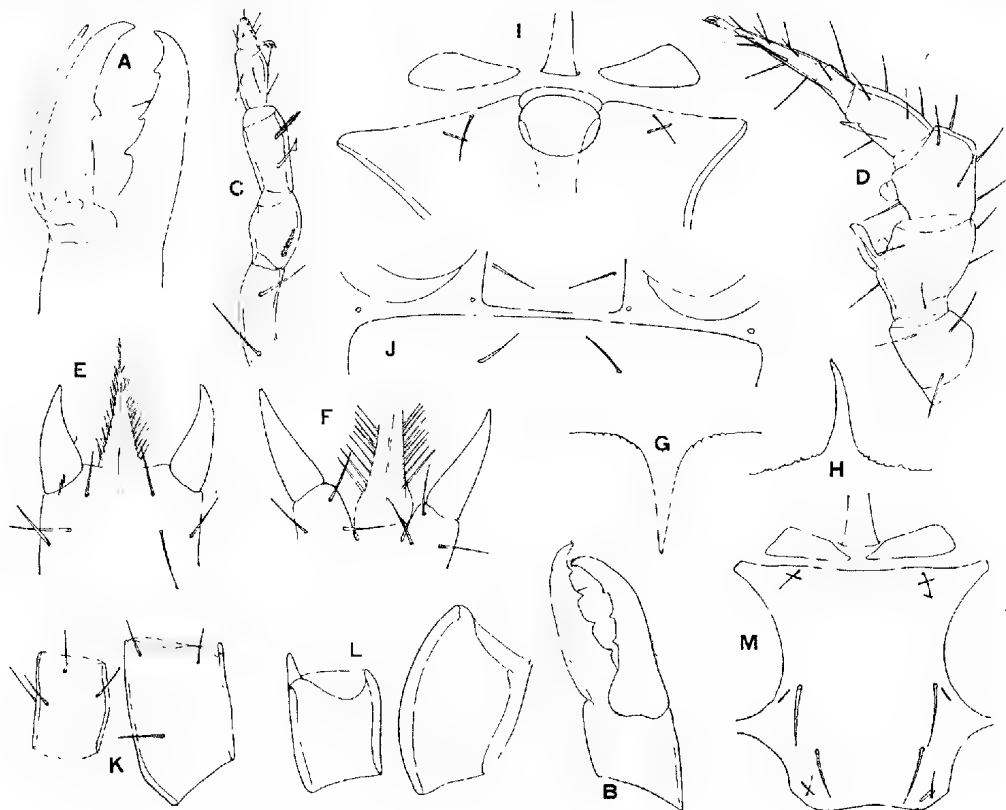


Fig. 6. A-M *Hydrogamasus relatus* n. sp.: A, mandible ♂; B, same ♀; C, palp ♂; D, leg II ♂; E, labial cornicles ♀; F, same ♂; G, H, epistome; I, prae-endopodal shields and male genital foramen; J, apex of ventrianal and base of epigynal shields ♀, showing inguinalia; K, trochanter III and IV ♂; L, same ♀; M, sternal shield ♀.

trochanter IV at most with indistinct posterior spine-like process; trochanter III with longer tooth. The outer inguinal plates situated within the outer corners of the ventrianal shield.

*Male*—As in female and in male of *H. dentatus*. Mandibles: process of movable chela long and slender and reaching tip of chela which has only a single median tooth; fixed chela with three teeth. Palpi apparently without the sensory apical peg. Labial cornicles pedunculate. Legs: II with a strong apophysis and an axial knob on the femur, an inner boss on the genu and an inner blunt spine-like process on tibia; trochanters without pronounced teeth.

*Loc.*—Glen Osmond, South Australia, in moss, June and July 1934 (three ♀♀, one ♂).

***Hydrogamasus relictus* n. sp.**

(Fig. 7, A-L)

*Female*—Length 750  $\mu$ , width 370  $\mu$ . Not so heavily chitinised as in preceding species, with usual reticulations on the dorsal and ventral shields; dorsal setae anteriorly 40  $\mu$  long, increasing to 65  $\mu$  posteriorly. Epistome with simple median mucro, with sides of base at an angle of about 45° and with fine serrations. Mandibles (fig. 7 G): movable chela with three teeth, fixed chela with five teeth.



Fig. 7. A-L *Hydrogamasus relictus* n. sp.: A, dorsal ♀; B, venter ♀; C, labial cornicles ♀; D, epistome ♀; E, mandibles ♂; F, same, another view; G, same ♀; H, palpi ♂; I, labial cornicle ♂; J, leg II ♂; K, trochanters III and IV ♀; L, prae-endopodal shields and ♂ genital foramen.

Labial cornicles (fig. 7 C) sessile. Palpi as in preceding species. Prae-endopodal shields as in fig. 7 B, anterior and posterior margins almost parallel. Sternal shield as in fig. 7 B, the second and third pairs of setae only slightly stronger than first and second pairs. Legs: I 585  $\mu$ , II 420  $\mu$ , III 370  $\mu$ , IV 550  $\mu$ ; II and IV somewhat stouter than I and III; trochanters III and IV without any pronounced apical teeth. Outer inguinal shields within the antero-lateral corners of ventrianal shield.

*Male*—Dimensions generally as in female and general features as in *H. dentatus* ♂. Mandibles: process of movable chela short, only two-thirds length

of chela and much bent and stout; fixed chela with only a single median tooth, movable chela with two small and two large teeth (fig. 7 E, F). Palpi apparently without the apical sensory cone of *H. dentatus*. Labial cornicles pedunculate. Legs: lengths approximately as in female, II with strong curved apophysis and two axillary lobes on femur, two large lobe-like protuberances on genu, and inner stout spine on tibia; trochanters without pronounced teeth.

*Loc.*—Queensland: in moss, Brisbane, October 1934. South Australia: in moss, Adelaide, 1935; Glen Osmond, in pine needles, 1935.

var. **major** n. v.

Differing from the typical form only in the size. Female: length 1,000  $\mu$ , width 500  $\mu$ ; dorsal setae 55  $\mu$  to 115  $\mu$ ; legs I 835  $\mu$ , II 635  $\mu$ , III 520  $\mu$ , IV 920  $\mu$ .

*Loc.*—Victoria: Sassafras, December 1931, in moss, 1 ♀ (H. G. A.). New Zealand: Bourke's Bush, Waimamaku, Auckland, October 1938, two ♀♀ (E. D. P.).

**Hydrogamasus australicus** n. sp.

(Fig. 8, A-R)

*Female*—Length 835  $\mu$ , width 470  $\mu$ . Shape ovoid but posterior half more tapering than in preceding species. Usual fine reticulations on dorsal and ventral shields. Dorsal setae 48-50  $\mu$  long, fine. Epistome with a median mucro which is only faintly tridentate apically, sides of base concave with at most indistinct crenulations. Mandibles as in fig. 8 G, movable chela with three teeth, fixed chela with two small teeth in front of "pilus dentarius" and three strong ones behind. Labial cornicles sessile. Palpi as in preceding species. Prae-endopodal shields as in fig. 8 B with almost parallel anterior and posterior margins. Sternal shield (fig. 8 B) with four pairs of setae, second and third pairs stronger than first and fourth pairs, apices of anterior arms separated. Legs: I 800  $\mu$ , II 600  $\mu$ , III 550  $\mu$ , IV 750  $\mu$  long, II and IV stouter than I and III; trochanters III with a posterior apical lobe-like tooth, IV with a short anterior apical tooth. Lateral inguinal plates well outside of the antero-lateral corners of the ventrianal shield (fig. 8 B).

*Male*—Size and dimensions as in female, and general features as in *H. dentatus*. Mandibles: process of movable chela stout and much bent over the correspondingly bent chela, movable chela with one tooth; fixed chela with three teeth (fig. 8 H). Palpi on the second segment without the apical peg of *H. dentatus*. Labial cornicles pedunculate. Legs: lengths approximately as in female, II with strong blunt process and a special seta on the inner apical angle, but no axillary tubercles on femur, genu with two short blunt processes, and the usual spine on the tibia (fig. 8 N); trochanters without pronounced teeth.

*Deutonymph*—Length 700  $\mu$ , width 420  $\mu$ . Dorsally with two shields as in fig. 8 Q. Ventrally with the prae-endopodal shields not in evidence; sternal shield reaching posterior margin of coxae IV, sides tapering from between coxae II and III, with four pairs of setae. Behind coxae IV laterally are a pair of small disc-like plates. Anal plate small, somewhat quadrate. There are eight pairs of setae on the venter with another pair between apex of sternal shield and coxae IV. Peritreme only reaching to coxae II.

*Loc.*—Queensland: Brisbane, in moss, October 1934, three ♂♂, two ♀♀, one deutonymph.

The above species of *Hydrogamasus* are all very closely related, differing only in minute details. They may be separated by the following key, which for comparison includes the Antarctic species *H. antarcticus* Trägårdh.



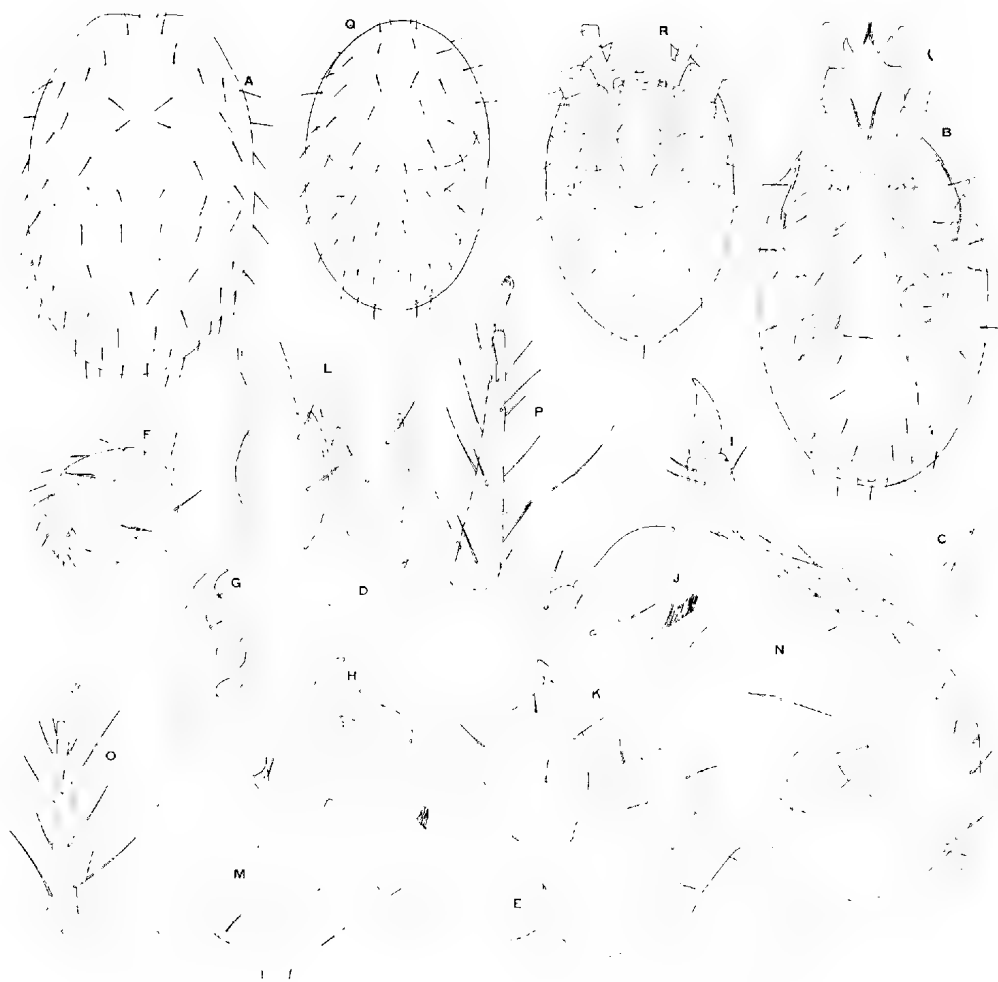


Fig. 8. A-R *Hydrogamusus australicus* n. sp.: A, dorsum ♀; B, venter ♀; C, epistome ♀; D, E, epistome ♂; F, palp ♂; G, mandible ♀; H, same ♂; I, labial cornicle ♂; J, same ♀; K, trochanters III and IV ♀; L, same ♂; M, prae-endopodal shields and male genital foramen; N, leg II ♂; O, tarsus leg III; P, same, leg IV; Q, deutonymph, dorsal; R, same, ventral.

#### KEY TO THE ANTARCTICUS GROUP OF THE GENUS *HYDROGAMUSUS*

♂ ♂

- 1 Tarsus of second leg with an outer short blunt process near the base. Movable chela of mandibles with one tooth, and long slender process; fixed chela with 2 teeth. Epistome triangular with median mucro nearly half the length, edges laterally with about 10 small teeth. *H. antarcticus* Träggh.  
Tarsus of second leg without process. Epistome not such a triangle, median mucro longer. 2
- 2 Process on movable chela of mandible long and slender, parallel-sided, and reaching tip of chela. Movable mandibular chela with 1 tooth, fixed chela with 3 teeth.  
Process of movable chela of mandibles stouter. *H. relatus* n. sp. 3
- 3 Chelae of mandibles subequal in length.  
Movable chela of mandibles much shorter than fixed; process as long as, and overlapping chela; movable chela with 1 tooth, fixed chela with 3 teeth. *H. australicus* n. sp. 4

- 4 Process of movable chela only two-thirds length of chela; movable chela with 1 tooth, fixed chela with 2 small teeth in front of "pilus dentarius," and two equally small teeth behind. *H. relictus* n. sp.

Process of movable chela reaching almost tip of chela; movable chela with 1 tooth, fixed chela with 3 large teeth. *H. dentatus* n. sp.

♀ ♀

- 1 Trochanter IV with prominent posterior apical tooth. Mucro of epistome apically tridentate, as long as base, base with sides finely toothed and forming an angle of 45°; movable chela of mandibles with 3 teeth, fixed chela with 5 teeth.

*H. dentatus* n. sp.

Trochanter IV at most with indistinct posterior teeth.

- 2 All trochanters without distinct apical teeth.

Trochanter III with either an apical anterior tooth, or an apical posterior blade-like tooth.

- 3 Mucro of epistome about half the height of epistome and its sides almost in line with the sides of base, which in the distal half have 8-10 small teeth.

*H. antarcticus* Trägårdh

Mucro about three-fourths length of epistome, its sides forming a distinct angle with the sides of the base; apically the sides of mucro have a minute tooth, and the sides of the base only very fine serrations.

- 4 Length to 750  $\mu$ .

*H. relictus* n. sp.

length to 1,000  $\mu$ .

*H. relictus* v. *major* n. v.

- 5 Trochanter III with an anterior apical blunt tooth. Lateral inguinalia within the angle of the ventrianal shield.

*H. relatus* n. sp.

Trochanter III with a posterior blade-like apical tooth. Lateral inguinalia outside of the angle of the ventrianal shield.

*H. australicus* n. sp.

Vitzthum 1929 (Tierwelt Mitteleuropas, Bd. III, Acari, 17) in his key to the Parasitidae defines the genus *Hydrogamasus* as follows: "Rückenschild einheitlich, auch bei den Jugendstadien, ohne seitliche Einschnitte." Halbert 1920 (Proc. Roy. Irish Acad., 35, 137), however, has shown that in the deutonymph and protonymph stages of *H. littoralis* G. & R. Can. (= *salinus* Laboulbène) there are two dorsal shields present. Similarly, I have described and figured (Aust. Antarct. Exped. Sci. Repts., vol. x, pt. 6, 1937) the deutonymph of *H. antarcticus* Trägårdh from Macquarie Island with two dorsal shields, and in the present paper the deutonymph and protonymph of *H. dentatus* and deutonymph of *H. australicus* are also shown to have two dorsal shields. According to the figures of *H. littoralis* (Berlese, Redia, fasc. 68, No. 5, 6) the jugularia (prae-endopodal shields of Trägårdh, Arkv. f. Zool, 7, No. 28, 20, 1912) consist of two pairs of small plates, none of which bear setae, and are therefore not true jugularia in Trägårdh's sense. Similarly, Berlese, in describing *H. silvestrii* (Zool. Anz., 1904, 27, 28), refers to the two pairs of jugularia (prae-endopodal shields) of both *H. littoralis* and *H. giardi* (Berl. et Troues.). In all the species described since *littoralis* and *giardi*, only a single pair of prae-endopodal shields occurs. This difference alone seems to suggest that these later species should constitute at least a new subgenus. In addition, the epistome of *H. littoralis* is triangular with three teeth, the median of which does not form a distinct mucro as in the group of species of which *antarcticus* may be taken as typical.

*Hydrogamasus silvestrii* Berl. 1904, from Italia, is also unique amongst the known species of this genus in the unusual and more complicated structure of the epigynium and should probably have a new genus erected for it.

#### Genus GAMASIPHIS Berlese 1904

Acari nuovi, Maniplus 2, in Redia, vol. i, fasc. 2, 1903, 261 (Genotype *G. pulchellus* Berlese); Trägårdh 1907, Swedish South Polar Exped., Bd. v. Liefg. II, Acari, 10.

Neoparasitidae with the dorsal shield entire in both sexes. Female with the ventrianal shield posteriorly coalesced with the underlapping dorsal shield; sternal shield with four pairs of setae, *i.e.*, consisting of the fused jugular, coxal and metasternal shields, the third pair of sternal setae situated much nearer the median line than the others, fourth endopodal shields free; epigynum with rounded anterior margin fitting under the posterior margin of sternal shield, with one pair of posterior setae; ventrianal shield large, separated from the epigynum and from the dorsal shield for about four-fifths of its length by a gradually narrowing suture; peritremal shields coalesced with the parapodial shields which extend well beyond coxae IV; in the angle between ventrianal, epigynal and parapodial shields is a conspicuous round shield. Prae-endopodal shields a single pair in both sexes. Male with the ventrianal shield separated from the sternal by a thin suture; sternal shield with five pairs of setae, all four endopodal plates fused with it; ventrianal separated from parapodial shields by a narrow suture and from dorsal shield for four-fifths of its length by a gradually narrowing suture, or the ventrianal entirely fused with the epigynal and dorsal shields; mandibles with a strong but free process on the movable chela; femur of leg II with a strong curved apophysis. Epistome in both sexes with long median mucro and two short lateral teeth.

GAMASIPHIS FEMORALIS (Banks 1916)

*Cyrtolaelaps femoralis* Banks 1916, Trans. Roy. Soc. S. Aust., xl, 228.

(Fig. 9, A-K)

Colour yellowish-brown. Shape oval, rounded behind.

*Female*—Length to 835  $\mu$ , width 500  $\mu$ . Epistome with long stout median mucro and two lateral mucrones about one-quarter length of median. Mandibles (fig. 9, E, F): movable chela with three blunt rounded teeth in front of "pilus dentarius" and three large rounded teeth behind. Prae-endopodal shields strongly chitinised anteriorly and posteriorly but the intermediate horizontal strip membranous, suggesting the division into two shields. Sensory organ on palp III as in fig. 9, K. Ventrianal shield with twelve setae, short and fine, in addition to the adanal and postanal setae. Legs: I 665  $\mu$ , II 500  $\mu$ , III 420  $\mu$ , IV 635  $\mu$ ; all tarsi with short caruncles and claws.



Fig. 9, A-K *Gamasisiphis femoralis* (Banks): A, venter ♂; B, venter ♀; C, epistome ♂; D, same ♀; E, mandible; F, same ♀; G, labial cornices ♀; H, same ♂; I, prae-endopodal and sternal shields ♀; J, leg II ♂; K, palpal fork.

*Male*—As in female, length to 750  $\mu$ , width 470  $\mu$ . Epistome as in female. Mandibles (fig. 9, E): movable chela strongly curved in apical half, with one median blunt tooth, and with strong calcar process apparently fused for basal two-thirds then free and following curve of chela, and at the extreme tip bifurcate; fixed chela with one tooth beyond "pilus dentarius" and two behind. Ventrianal shield separated from dorsal shield for almost the same distance as in the female. Prae-endopodal shields as in female. Legs: lengths as in female. II with a stout apical inner process on femur, a similarly placed small blunt lobe on genu, and a small tooth on tibia. Dorsal setae in both sexes 60-80  $\mu$  long, fine, but apically with a pair of setae 120  $\mu$  long.

*Loc.*—Tasmania: Evandale Junction, with *Ectatomma metallicum* (A. M. L.). South Australia: Adelaide, 1935, in moss (H. W.); National Park, Belair and Long Gully in moss, September, 1935, (H. W.).

*Remarks*—There is no doubt that Banks' *Cyrtolaclaps femoralis*, the single specimen of which is in the collection of the South Australian Museum, is erroneously placed. A comparison of Banks' figures, especially of the sternum and epigynium, with the present figures from new material will prove this.

#### Genus *Austrogamasus* nov.

Neoparasitidae—Female with entire dorsal shield which postero-laterally underlaps the venter. Legs long and slender; tarsi with short caruncle and paired claws. Fork on palpal tarsus three-pronged. Epistome rounded with numerous short spines or teeth. Prae-endopodal and fourth endopodal shields free. Sternum with three pairs of setae. Metasternal shields absent, but represented by the usual seta and pore. Genito-ventral shield elongate, posterior margin squarish and adjacent to anal shield, with only a single pair of setae definitely on the shield. Male unknown.

This genus ventrally closely resembles *Gymnolaclaps* of the Laelaptidae and the species might almost be placed there but for the three-pronged fork on the tarsus of the palpi.

#### AUSTROGAMASUS GRACILIPES (Banks 1916)

(Fig. 10, A-E)

*Cyrtolaclaps gracilipes* Banks 1916, Trans. Roy. Soc. S. Aust., 40, 228.

*Female*—Shape oval, but tapering rapidly posteriorly. Colour, deep orange-brown. Strongly chitinised. Length 920  $\mu$ , width 635  $\mu$ . Dorsal shield covering entire dorsum and, behind coxae IV, underlapping the venter; dorsal setae (fig. 10, A) long, and fine, 65  $\mu$ . Venter; tritosternum with short base, prae-endopodal shields present, but lightly chitinised and indistinct; sternal shield barely extending to middle of coxae III, with three pairs of setae; metasternalia only represented by a seta and pore; fourth endopodal shields free and distinct; epigynial and ventral shield coalesced, with a single pair of setae on level of posterior edge of coxae IV, elongate with only slightly convex sides, and reaching apex of anal shield, with truncate end, there are three other pairs of setae which are hardly on the shield; anal shield sub-rotund with anus in posterior half and the usual circumanal setae; behind coxae IV and on each side of genito-ventral shield are three small inguinalia, the outer ones of which are elongate; peritremal shields narrow and posteriorly only reaching coxae IV.

Mandibles as in fig. 10, D. Epistome rounded medially, more flattened laterally, with small fine teeth extending right across.

*Loc.* (two females)—Victor Harbour, South Australia. May, 1939 (J. S. W.).

Recorded by Banks 1916 (as *Cyrtolaclaps*) from Sydney and Liverpool, New South Wales, and from Lal Lal, Victoria, as in association with the ants *Ponera*

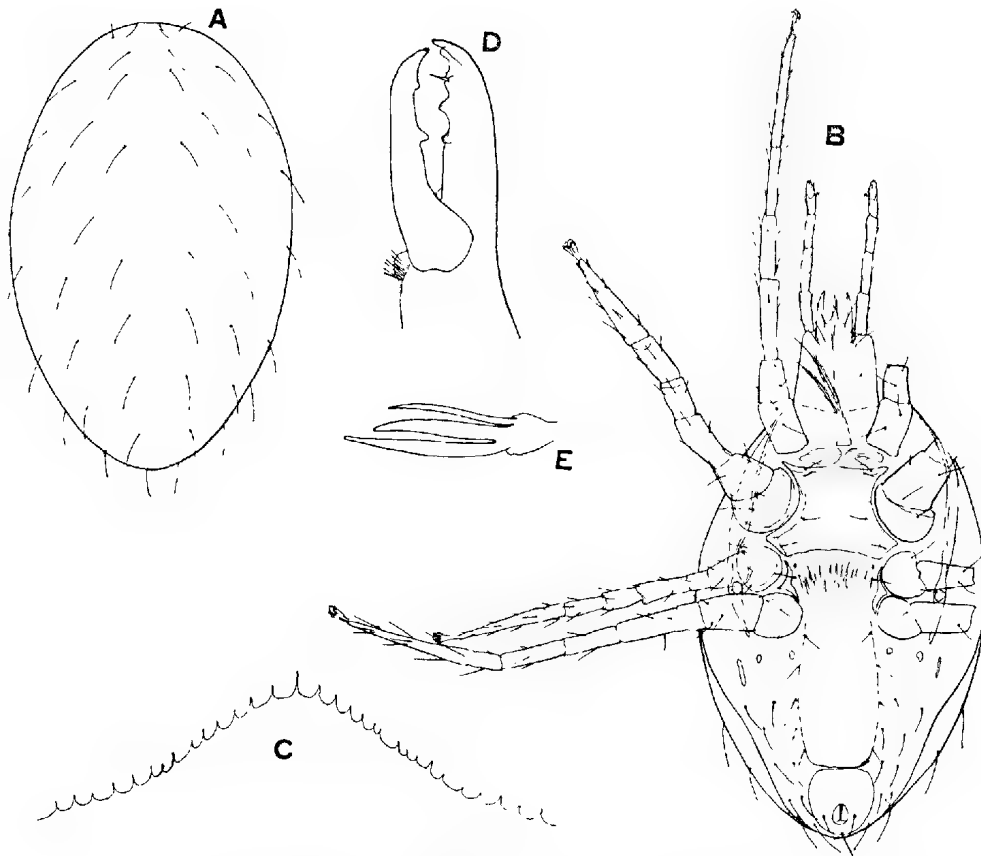


Fig. 10, A-E *Austrogamasus gracilipes* (Banks): A, dorsal; B, ventral, C, epistome; D, mandible; E, fork of palpal tarsus.

*lutea*, *Camponotus nigriceps*, *Ectatomma metallicum*, and *Polyrachis hexacantha*, collected by A. M. Lea.

Family GAMASOLAEALPTIDAE Oudemans 1939

Zool. Anz., 1939, 126, (1 2), 22, nom. nov. for Metaparasitidae Oudemans, 1906.

As in Neoparasitidae, but with two dorsal shields.

In this family Oudemans (*loc. cit.*) includes the genera *Digamasellus* Berl. 1903, *Euryparasitus* Ouds. 1901, *Gamasodes* Ouds. 1939, *Gamasolaelaps* Berl. 1903, *Halolaelaps* Berl. et Trt. 1889, and *Rhodacarellus* Willm. 1936.

Genus DIGAMASELLUS Berlese 1905

Redia 2, 234.

Dorsal shield divided, sternal shield consisting of fused jugularia, coxal and metasternal shields; prae-endopodal shields present (sometimes two pairs or subdivided) or ? absent; fourth endopodal shields free. Epigynial shield separated from sternal, and ventrianal with rounded anterior margin and straight posterior margin. Ventral and anal shields coalesced, large, occupying most of venter. Epistome with a single mucro or trispinous. Leg I with claws much smaller than rest and on distinct but short peduncles. Fork on palpal tarsus three-pronged. Male with calcar appendage on movable chela of mandibles, and leg II strongly armed.

Owing to lack of literature, particularly Berlese's description of the type species *Gamasus pusillus*, I am a little uncertain as to the placing of the following species in this genus, and the above generic characters are largely drawn from the material before me.

? *Digamasellus concina* n. sp.

(Fig. 11, A-M)

Colour yellow-brown, well chitinated. Length to  $650\mu$ , width to  $450\mu$ . Dorsal shields two, separated by a narrow suture, anterior shield with the front

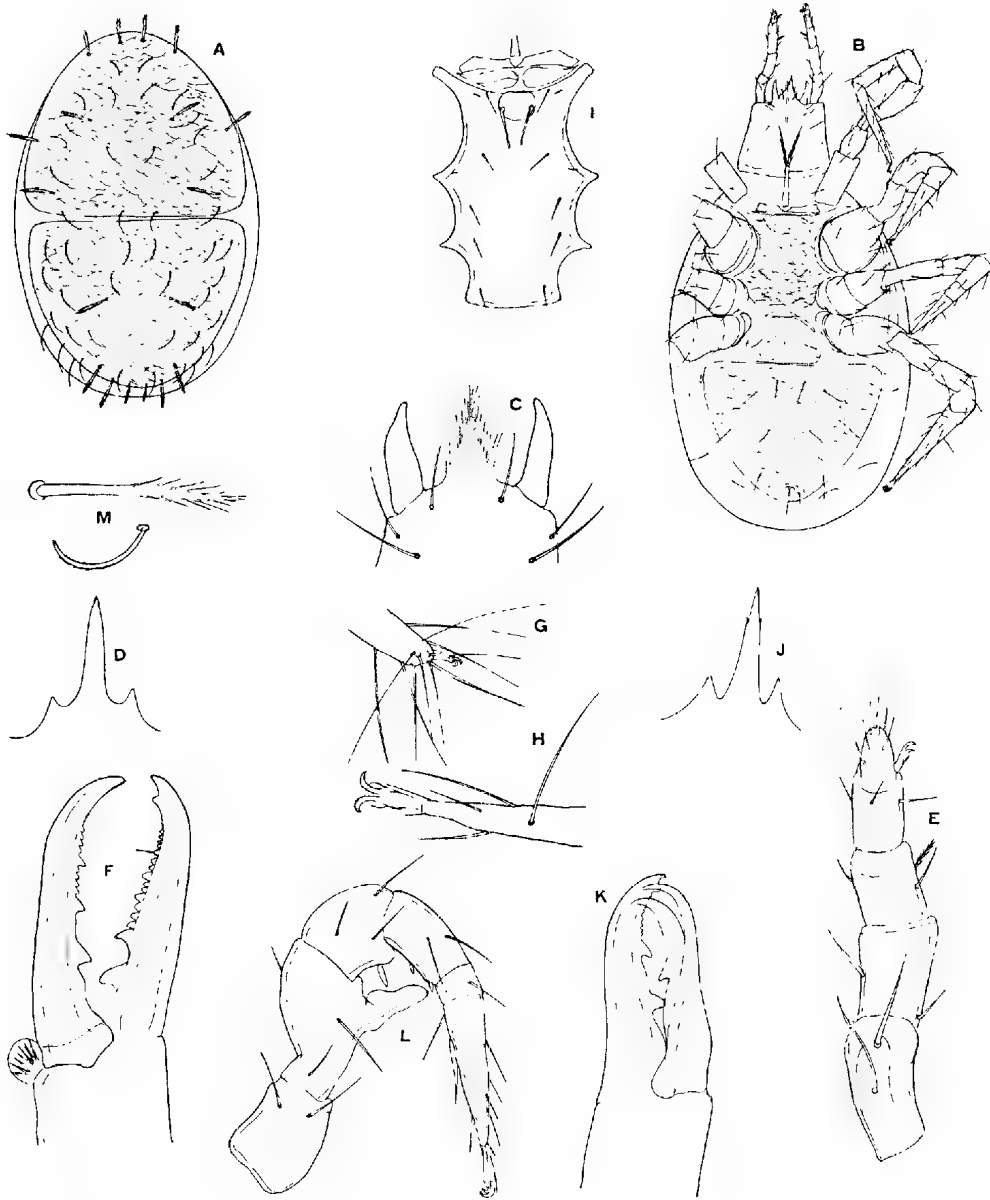


Fig. 11, A-M *Digamasellus concina* n. sp.: A, dorsum ♀; B, venter; C, labial cornicles ♀; D, epistome ♀; E, palp ♀; F, mandible ♀; G, tip of leg I ♀; H, tip of leg III ♀; I, sternal shield ♂; J, epistome ♂; K, mandible ♂; L, leg II ♂; M, dorsal setae

portion of its lateral margins adjacent to body margins, posterior with margins well separated from body margin, both shields with reticulations. Epistome trispinous with long median mucro and short lateral mucrones.

*Female*—Sternal, genital and ventrianal shields with fine reticulations. Prae-endopodal shields either divided or in two pairs, consisting of a large anterior rectangular pair, and a posterior linear pair. Ventrianal shield with 10 setae besides the adanal and postanal setae. Palpi as in fig. 11 E, femur with two long strong setae, tibia with an outer ciliated seta. Median mucro of epistome simple. Labial cornicles as in fig. 11, C. Mandibles (fig. 11 F); movable chela with three prominent teeth and a series of small teeth between apex and first tooth and between first and second teeth; fixed chela with two large basal teeth, then a series of small teeth and another large one before apex. Dorsal setae of two kinds, long straight, somewhat clavate, ciliated setae,  $46\ \mu$  long, and shortly curved, only indistinctly ciliated setae  $30\ \mu$  long, arranged as in fig. 11, A. Legs I  $585\ \mu$ , II  $420\ \mu$ , III  $410\ \mu$ , IV  $500\ \mu$  long (fig. 10, G, H).

*Male*—Very similar in dimensions and dorsal shields to female. Epistome with median mucro apically tridentate. Mandibles; movable chela with calcar process free in apical half, with a single median tooth; fixed chela with a sub-basal and a median large tooth, then a series of fine teeth and a large tooth before apex. Sterno-genital shield separated from ventrianal, with five pairs of setae. Prae-endopodal shields in two pairs, the anterior pair more or less rectangular, posterior pair pear-shaped with bases inwards. Leg II thickened, as in fig. 11 L, with a strong inner subapical calcar process, and a small stout inner spine-like process on genu.

*Loc.*—In moss, Long Gully, South Australia, August 1938 (7 ♀♀, 1 ♂).

### ? *Digamasellus punctatus* n. sp.

(Fig. 12, A-L)

Colour yellowish-brown, well chitinised. Length both sexes to  $700\ \mu$ , width to  $400\ \mu$ . Dorsal shields two, well separated by a suture a little posterior of the middle, anterior only adjacent to body margin at the front end, posterior shield well separated from body margin but nearer apically than at sides, both shields strongly rugose with uniform, ciliated, somewhat bushy setae. Epistome with a simple median mucro, but base laterally with numerous pronounced small teeth.

*Female*—With only one pair of prae-endopodal shields as in fig. 12 B, sternal shield consisting of coxal, jugular and metasternal shield combined, with only indistinct reticulations; fourth endopodal shields free; ventrianal shield large, with twelve setae besides the adanal and postanal setae, laterally of the anterior corners of ventrianal shield are a pair of small elongate shields; epigynial shield as in fig. 12, B. Palpi (fig. 12, J), on tibia with two unciliated sensory setae as figured. Epistome as in fig. 11, D. Mandibles (fig. 12, C); movable chela with three large teeth, fixed chela with five teeth. Legs I  $585\ \mu$ , II  $420\ \mu$ , III  $340\ \mu$ , IV  $500\ \mu$  long, claws of I very small and on very short but distinct peduncle.

*Male*—Size and dimensions of shields and legs as in female. Ventrianal shield (fig. 12, E) very wide, occupying almost whole of venter. Epistome as in fig. 12, G. Only one pair of prae-endopodal shields. Mandibles (fig. 12, F); movable chela with one median tooth, and the calcar process shorter than chela and apically free, fixed chela with three teeth. Leg II (fig. 12, K) with femoral process and apical spine-like tooth or geni.

*Loc.*—South Australia: Adelaide, June, 1935 (1 ♀); National Park, Long Gully and Belair, August 1938 (2 ♀♀, 6 ♂♂).

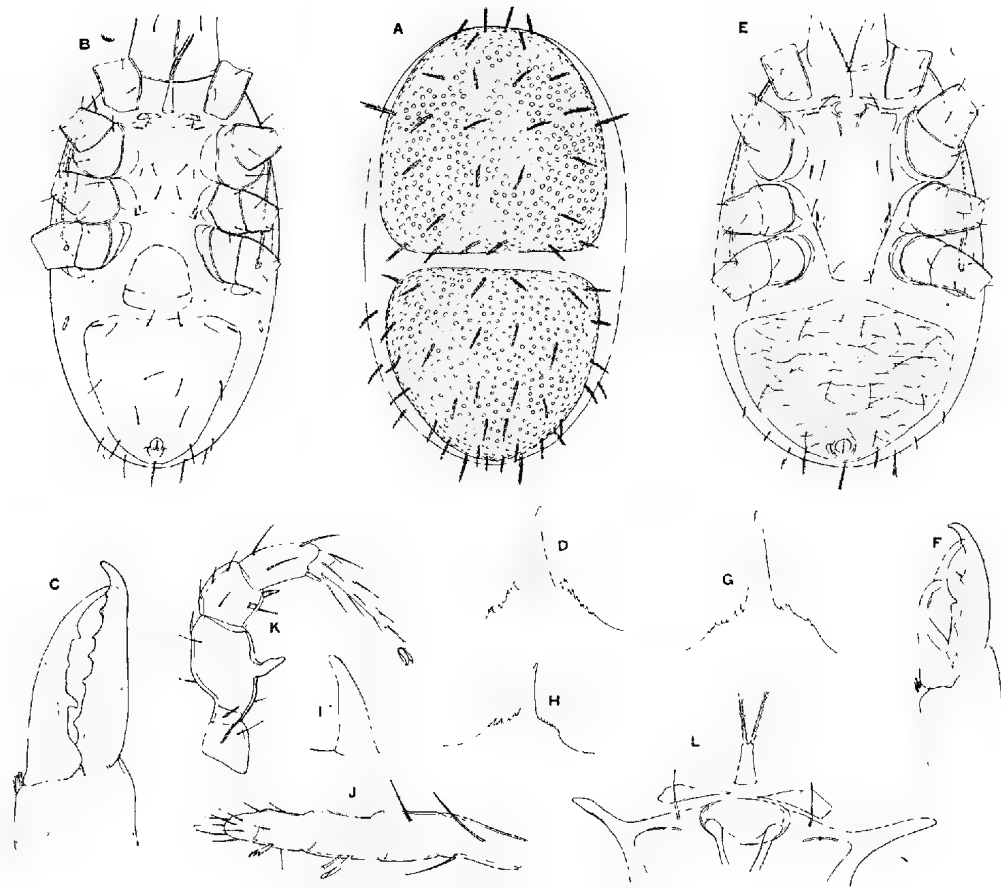


Fig. 12. A-L *Digamasellus punctatus* n. sp.: A, dorsum ♀; B, venter ♀; C, mandibles ♀; D, epistome ♀; E, venter ♂; F, mandible ♂; G, epistome ♂; H, same of another specimen; I, right labial cornicle ♂; J, palp ♂; K, leg II ♀; L, anterior end of sternal shield ♂.

? *Digamasellus tragardhi* n. sp.

(Fig 13, A-F; 13A, A-D)

*Female*—Shape a rather broad oval. Length  $580\mu$ , width  $370\mu$ . Dorsal shield strongly chitinated, subdivided by a suture at midway. Dorsal and ventral shields with fine reticulations. Dorsal setae as in fig. 13, A, F of two kinds, some including the scapula setae rather clavate and bushy  $40\mu$  long, the others strongly curved and scythe-shaped,  $50\mu$  long. Prae-endopodal shields in three pairs (fig. 13, B); sternal shield consisting of jugular, coxal and metasternal shields coalesced; fourth endopodal shields free. Epigynial shield with rounded anterior margin and straight posterior margin, with two setae placed laterally and well forward of the posterior margin. Ventrianal shield large with 12-14 setae besides the adanal and postanal setae. Epistome five-spined with the median nuero much the longest. Mandibles as figured, fixed chela with seven teeth, movable chela with three teeth. Fork of palpal tarsus three-pronged; the lowest prong very small as in the previous species. All legs short and thick, claws of leg I small, on short but distinct peduncle; some of the dorsal setae on femora of all legs moderately stout, length of leg I  $500\mu$ , II  $420\mu$ , III  $385\mu$ , IV  $520\mu$ .

*Male*—As in female with relatively short thick legs. Length  $585\mu$ , width  $420\mu$ . Dorsal shields and chaetotaxy as in female. Mandible as in fig. 13A, B,



movable chela with strong curved calcar process and overlapping tip of chela. Epistome (fig. 14, A) quinquispinous. Sternal shield (fig. 14, C) with five pairs of setae and three pairs of pores; genital foramen large, prae-endopodal shields divided into three pairs. Leg II with stout apophysis on femur and small one on genu (fig. 14, D).

*Loc.*—A single ♀ from moss, Adelaide, June 1935; five ♂♂ in moss, Bridgewater, South Australia, August 1942 (J. S. W.).

*Remarks*—This interesting species is doubtfully placed in this genus, from the other species of which it differs in the short thick legs, especially I, and the five-spined epistome.

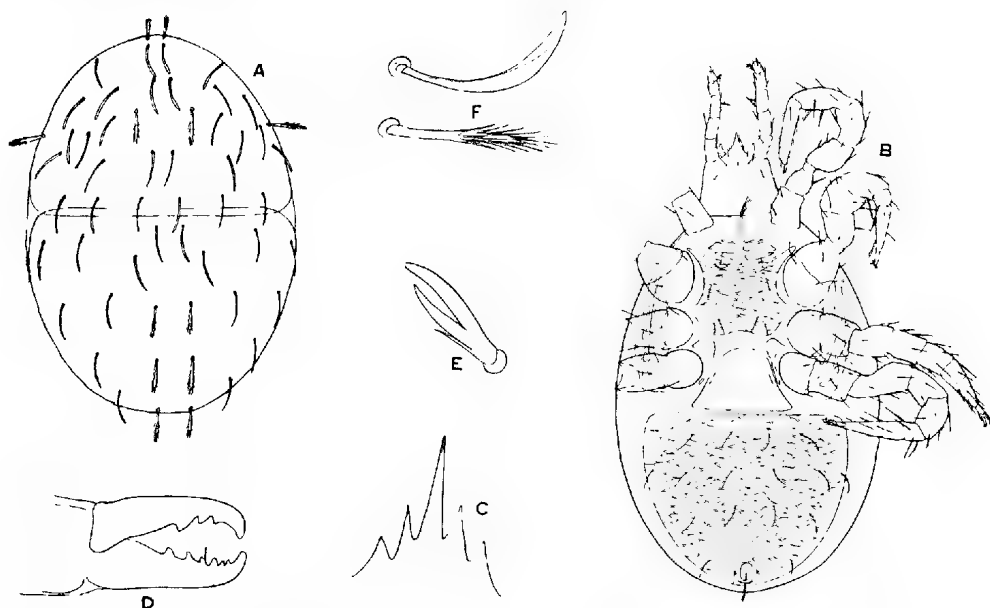


Fig. 13 A-F *Digamasellus trægärdhi* n. sp.: ♀, A, dorsum ♀; B, venter ♀; C, epistome ♀; D, mandible; E, fork of palpal tarsus; F, dorsal setae.

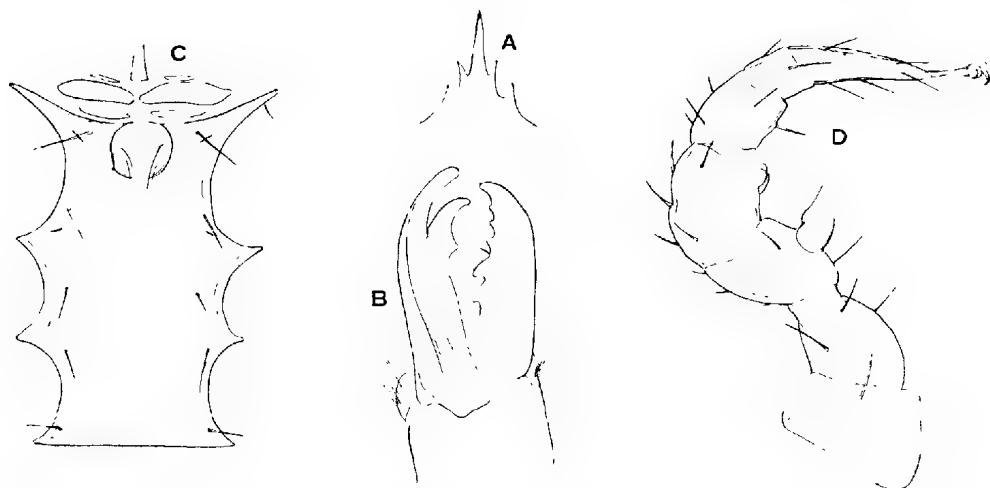


Fig. 13A, A-D *Digamasellus trægärdhi* n. sp. ♂: A, epistome; B, mandible; C, sternal shield; D, leg II.

? *Digamasellus semipunctatus* n. sp.

(Fig 14, A-B)

*Description*—Strongly chitinised yellowish species, shape egg-like. Length 850  $\mu$ , width 500  $\mu$ . Dorsal shields two, distinctly separate, anterior with irregular rugosities or punctures, posterior with reticulate lines. Dorsal setae on shields uniformly ciliate and clavate, 65  $\mu$  long, except the apical pair on the posterior shield which are similar but shorter. The setae outside the anterior shoulders of the posterior dorsal shield are similar to those on the shield, but all the others (cf. fig. 14, A) are short, simple and curved. Prae-endopodal shields simple;

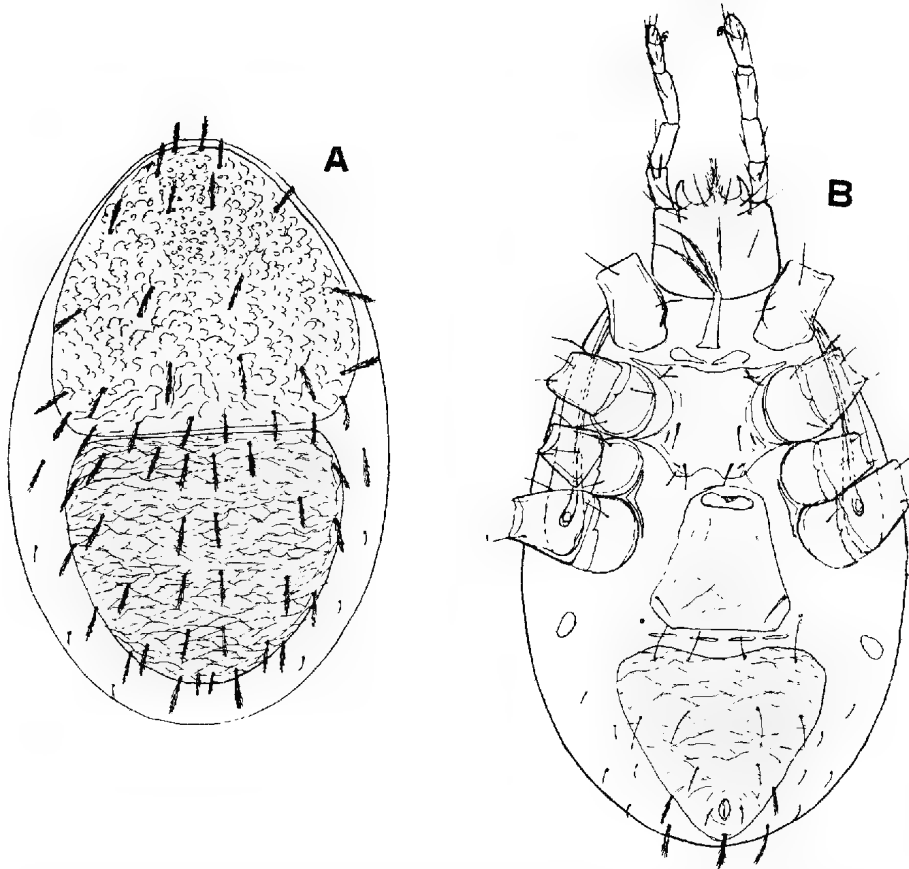


Fig. 14, A-B *Digamasellus semipunctatus* n. sp.: A, dorsum; B, venter.

sternal shield with four pairs of setae, the second and third pairs much stronger than the first and fourth; fourth endopodal shields free. Epigynial shield as in fig. 14, B with strongly chitinised sclerite on anterior wall of the vagina, with one pair of setae subpostero-lateral. Ventrianal shield large, subtriangular with ten simple fine setae and two ciliated setae, in addition to the circumanal setae, the postanal one of which is also ciliated. Between the epigynial and ventrianal shields is a transverse row of four small narrow horizontal shields, and outside of these is a pair of strong, rather large metapodial shields. The setae outside the ventrianal shield are small, fine and curved.

Legs, normal for the genus, the tarsi of leg I with a well-developed, although short peduncle.

The epistome is similar to that of *D. concina*.

*Loc.*—A single ♀ from moss, Bridgewater, South Australia, August 1942.

*Remarks*—This species is not only much larger than the others, but also differs from *D. punctatus* n. sp. (with which it agrees in having only one kind of setae on the dorsal shields) in that only the anterior dorsal shield has rugose punctures, the posterior having only reticulations. The above four species may be separated by the following key.

#### KEY TO THE AUSTRALIAN SPECIES OF DIGAMASELLUS

- |   |  |                            |
|---|--|----------------------------|
| 1 | Dorsal shields with only one kind of setae.  | 2                          |
|   | Dorsal shields with two kinds of setae.  | 3                          |
| 2 | Both anterior and posterior dorsal shields rugosely punctate. Size, to 700 $\mu$ . |                            |
|   | Only anterior dorsal shield rugosely punctate. Size, to 830 $\mu$ .                |                            |
|   |  | <i>D. punctatus</i> n. sp. |
| 3 | Legs of normal build. Epistome trispinous.   | <i>D. punctatus</i> n. sp. |
|   | Legs short and thick, especially I. Epistome quinquispinous                        | <i>D. concina</i> n. sp.   |
|   |  | <i>D. trögårdhi</i> n. sp. |

#### Family PACHYLAELAPTIDAE Vitzthum 1931

Result. Sci. du Voyage aux Indes. Orient. Néerlandaises 2, 1931, fasc. 5; Handbuch der Zool., 3, (2), Acari, 1931.

Here Vitzthum (loc. cit.) includes the genera *Pachylaelaps* Berlese 1888, *Onchodellus* Berl. 1904, *Megalaelaps* Berl. 1892, *Pachyscius* Berl. 1910, *Olopachys* Berl. 1910, *Elaphrolaelaps* Berl. 1910, *Sphaerolaelaps* Berl. 1903, *Brachylaelaps* Berl. 1910, *Platylaelaps* Berl. 1904, *Paraelaps* Trägårdh 1910, *Pachylaella* Berl. 1916, *Beauricuia* Ouds. 1929, *Neoparasitus* Ouds. 1901.

Of these Oudemans 1939 places the last two genera in the family Neoparasitidae.

#### Genus PACHYLAELAPS Berlese 1888

A.M.S. ital. Rept. 1888, fasc. 51, No. 10.

Ventral shield of female coalesced with epigynial. No prae-endopodal shields. Sternal shield with four pairs of setae, *i.e.*, it consists of the fused jugular, coxal and metasternal shields, and is only slightly differentiated from the epigynial. Anal shield free. Parapodial shield large and produced beyond coxae IV, where it lies closely adjacent to the ventri-epigynial shield. Epistome with a wide apex with many teeth. In male all ventral shields coalesced. Dorsal shield entire in both sexes. Leg II thicker than the rest in both sexes, tarsus II with two stout spines; leg IV of  $\delta$  with long flexible appendage to movable chela.

#### *Pachylaelaps australicus* n. sp.

(Fig. 15, A-K)

Broadly oval, well chitinised brownish-yellow. Length of  $\varphi$  to 900  $\mu$ , width to 590  $\mu$ ; length of  $\delta$  to 850  $\mu$ , width to 550  $\mu$ . Dorsal shield entire in both sexes, with pronounced hexagonal reticulations, with chaetotaxy as in fig. 15, A; setae 50-75  $\mu$  long. Venter  $\varphi$ ; all shields with pronounced reticulations, no prae-endopodal shields, sternal shield as in genus, posterior margin strongly concave, but only indistinctly separated from epigynial-ventral shield, parapodial shield large, posteriorly reaching well beyond coxae IV and its inner posterior margin overlapping lateral edge of ventri-epigynial shield, anal shield broadly triangular, outside of posterior prolongation of parapodial shield is a pair of elongate small plates as in *P. imitans* Berlese. Venter of  $\delta$  as in fig. 15, I, legs comparatively short, and II stouter than the rest in both sexes; I slender with small tarsal claws on short caruncle, and II apically with two stout spines, and in female with two other stout ventral spines, the caruncle arising from between the apical spines; in male leg II with strong blade-like truncate calcar process on femur. Palpi

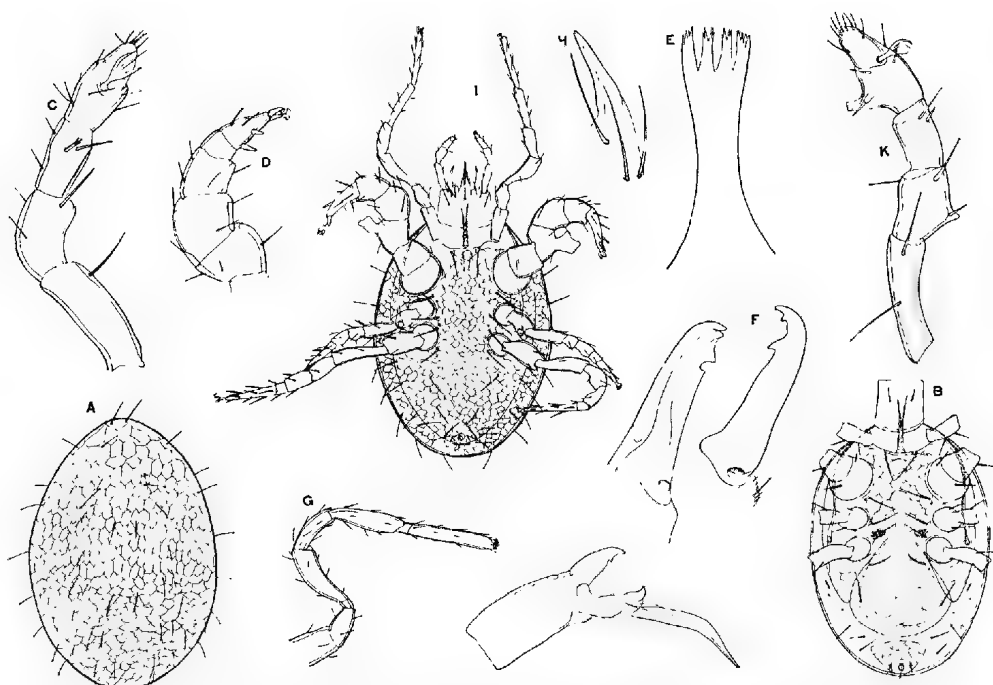


Fig. 15, A-K *Pachylaclaps australicus* n. sp.: A, dorsum ♀; B, venter ♀; C, palp ♀; D, leg II ♀; E, epistome; F, mandibular chelae; G, leg I ♀; H, right labial cornicle ♀; I, venter ♂; J, mandible ♂; K, palp of ♂.

(fig. 15, C, K) with tarsal fork three-pronged and prominent, tarsus in ♂ also on inner side with a stout square-ended process (fig. 15, K) somewhat different in shape from *P. imitans*. Epistome in general shape typical of genus, with four major apical teeth, each of which is apically subdivided into four small teeth (fig. 15, E). Mandibles ♀; movable chela with two subapical teeth, fixed chela with two subapical teeth; in ♂ movable chela without teeth and with a long calcar process as in fig. 15, J, fixed chela with one recurved subapical tooth.

Loc.—In garden soil, Glen Osmond, March, 1933. Four ♀♀, three ♂♂ (H. W.).

*Remarks*—This species appears to be very close to *P. imitans* Berl. 1920 (Redia 15, 184), as redescribed and figured by Beier 1931 (Sitzbericht Akad. Wissenschaft, Wien: Abt. 1, Bd. 9 u. 10 Hft., 140), but differs in the structure of the epistome, the palp and leg II of the male, and in the dentition of the mandibles.

Family MACROCHELIDAE Vitzthum 1931

Handbuch der Zool., 3, (8), Acarina, 1931.

Legs I without ambulacra and claws, exceptionally with ambulacra in *Neopodocinum* Oudms. Prae-endopodal shields present or absent. Epistome variable, usually fish-tail-shaped with an anterior fork. Female sternal shield usually with three pairs of setae and two pairs of pores corresponding to the coalesced jugular and coxal shields, sometimes with four pairs of setae and three pairs of pores, i.e., embracing the metasternal shields which are otherwise free; epigynial shield free, with rounded anterior margin and one pair of setae, often contiguous with the fused ventral and anal shields; ventri-anal shield usually large and occupying most of the venter with a variable number of setae. Male sternal shield with the genital opening under its anterior margin, with four pairs of

setae. Male with a calcar process on the movable chela of the mandibles and with the second leg and sometimes the fourth leg armed with processes.

In this family Vitzthum (*loc. cit.*) includes the genera *Neopodocinium* Oudms. 1902, *Podocinium* Berl. 1882, *Geholaspis* Berl. 1918, *Coprholaspis* Berl. 1918, *Nothrholaspis* Berl. 1918, *Macrocheles* Latr. 1829, *Holostaspella* Berl. 1904, *Macrholaspis* Oudms. 1931, *Prholaspina* Berl. 1918, *Gamasholaspis* Berl. 1904, *Calholaspis* Berl. 1918, *Parholaspis* Berl. 1918, *Holaspulus* Berl. 1904, *Holocelaeno* Berl. 1910, *Trichocelaeno* Berl. 1918, *Erholocelaeno* Berl. 1918, and *Trigonholaspis* Vitz. 1930.

Genus *MACROCHELES* Latreille 1829, Berlese 1918

In Cuvier R. Anim. ed. 2. 4, 282; Berlese 1918, Redia 13, fasc. 1, 172.

= *Holostaspis* Kolenati 1857, Berlese 1887, A.M.S. ital. Rept., fasc. 44, No. 2.

As in the family; leg I not much if at all longer than body. Dorsal shield not longitudinally carinate with depressed median area, well chitinised, entire. Sternal shield with three pairs of setae. Metasternal shields free and conspicuous. Ventrianal shield large, adjacent to posterior margin of epigynal shield, with three pairs of setae besides the circumanal setae. Sternal shield without definite median transverse lines, with small reticulate lines of rugosities which are more pronounced on posterior half. Epigynal, ventrianal and dorsal shield with hexagonal reticulations. Sternal shield without porous areas.

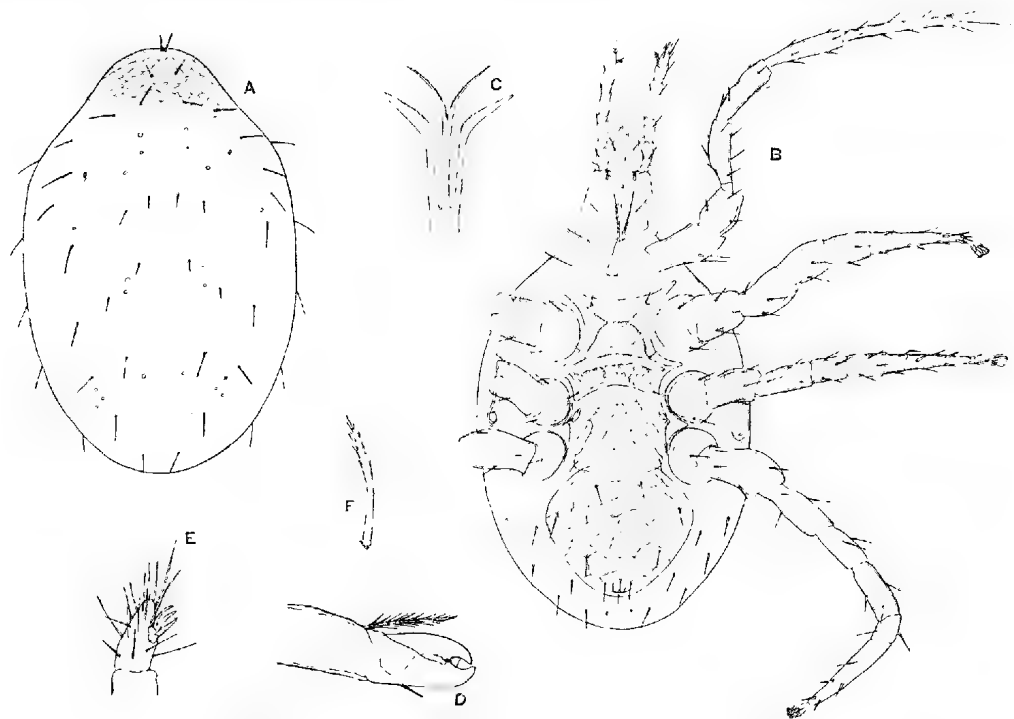


Fig. 16. A-F *Macrocheles vagabundus* v. *australis* Berl.: A, dorsum; B, venter; C, epistome; D, mandible; E, palpal tarsus; F, outer dorsal seta.

*MACROCHELES VAGABUNDUS* Berl. 1889, var *AUSTRALIS* Berl. 1918

(Fig. 16, A-F)

*Female*—Dark yellowish-brown strongly chitinised. Length to 1,200  $\mu$ , width to 700  $\mu$ . Venter: prae-endopodal shields wanting; sternal shield with the median transverse and oblique lines represented by small rugosities, posterior

hali with rather stronger rugosities (fig. 16,B); epigynial and ventrianal shields with fine reticulate hexagonal lines; endogynium with the usually rod-like lateral sclerites; ventrianal shield large, subpentagonal, with three pairs of setae, besides the adanal and postanal setae; fourth endopodal shields free. Epistome as in fig. 16,C. Mandibles with only a single subapical tooth on each chela. Legs II and IV somewhat stouter than I and III; I 820  $\mu$ , II 670  $\mu$ , III 750  $\mu$ , IV 1,080  $\mu$  long. Dorsal setae arranged as in fig. 16, A, all except the two median transverse rows of 4, 40  $\mu$  long and apically penicillate (cf. fig. 16, F); median ones fine, pointed, and 20  $\mu$  long.

*Loc.*—A fairly common species generally found attached to flies, principally species of *Musca*, as in all the following records:—New South Wales: Upper Orara via Karangi, April, 1937 (M. A. H.); Tweed River, February, 1928 (T. F. F.); Sydney, 1909 (T. H. J.); Bathurst, May, 1942. Queensland: Brisbane, May, 1941; Bustard Head, June, 1942. It was originally recorded by Berlese from "Sydney, Australia."

*Remarks.*—In most species of *Macrocheles* and allied genera, males are extremely rare, and all my material is of the female sex.

In the male as originally described by Berlese the femora of leg II and the trochanters of leg III and IV are shown as armed with processes and tubercles.

***Macrocheles coprophila* n. sp.**

(Fig. 17, A-E)

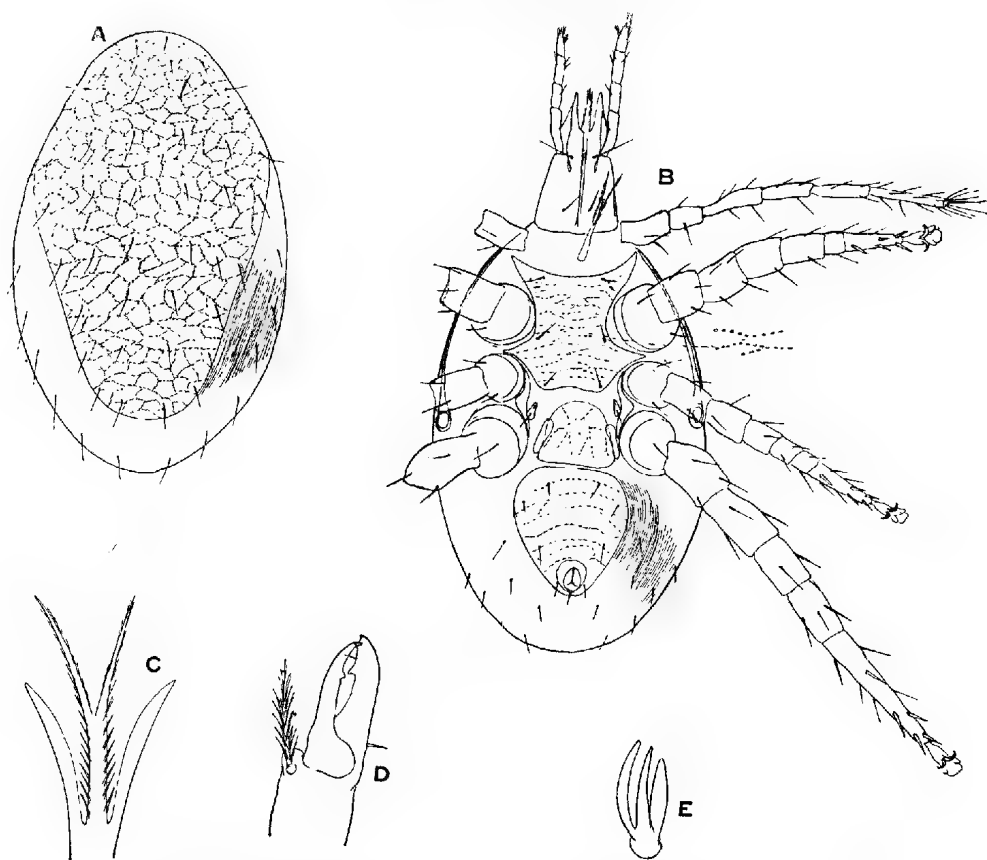


Fig. 17, A-E *Macrocheles coprophila* n. sp., ♀: A, dorsum; B, venter; C, epistome; D, mandible; E, palpal fork.

*Female*.—Yellowish-brown, moderately chitinated. Length to 1,000  $\mu$ , width to 700  $\mu$ . Venter: prae-endopodal shields wanting. Sternal shield without the median transverse and oblique lines but with a number of irregular transverse rows of minute rugosities (cf. fig. 17, B). Epigynial and ventrianal shields with similar lines of minute rugosities; endogynium with the usual lateral sclerites. Ventrianal shield only moderately large, about half as wide again as the base of the epigynial shield, subtriangular and longer than wide and with three pairs of setae besides the circumanal setae. Fourth endopodal shields free. Metasternal shields also free and conspicuous. Mandibles (fig. 17, D) with one subapical tooth on each chela. Epistome as in fig. 17, C.

Dorsal shield with fine hexagonal reticulations and setae as arranged, uniform and simple, 40  $\mu$  long; shield not completely covering abdomen, tapering for the posterior two-thirds; the cuticle outside of the shield longitudinally and finely striated. Legs I 780  $\mu$ , II 720  $\mu$ , III 750  $\mu$ , IV 1,000  $\mu$  long.

*Loc.*—Two females from manure heap, Bathurst, New South Wales, May 1932 (S. L. A.).

Genus *NOTHRHOLASPIS* Berlese 1918

Redia, 1918, 13, fasc. 1, 169.

Sternum variously and densely rugose, rugosities not reduced, transverse median line sometimes obsolete; porous areas sometimes present. Body and legs with scaly secretions. Dorsal setae penicillate.

*NOTHRHOLASPIS* ? *MONTIVAGUS* Berlese 1887

*Holostaspis montivagus* Berl. 1887, A.M.S. ital. Rept., fasc. 44, No. 4.

(Fig. 18, A-E)

Strongly chitinated dark-brownish species, the body and legs generally covered with a scaly secretion. Female: length to 1,400  $\mu$ ; width to 830  $\mu$ . Venter: prae-endopodal shields wanting; sternal, epigynial and ventrianal shields strongly rugose with the rugosities in clusters (fig. 18, B); sternal shield with three pairs of setae and two pairs of pores, reaching middle of coxae IV; metasternal shields free and distinct, but almost enclosed by the angle of sternal, epigynial and fourth endopodal shields. Ventrianal shield with a flattish anterior margin and then almost evenly rounded, about as wide as long, with three pairs of setae besides the circumanal setae. Fourth endopodal shields free. Epistome as in fig. 18, C. Mandibles (fig. 17, D), each chela with two blunt teeth. Legs, I 1,000  $\mu$  long, II 950  $\mu$ , III 950  $\mu$ , IV 1,400  $\mu$ . Dorsal shield entire, with fine reticulate hexagonal lines, except in the middle where the rugosities are as in fig. 18, A; setae mostly with coarse ciliations (fig. 18, E), 90  $\mu$  long, the median setae 120  $\mu$  long and not or only indistinctly ciliated.

*Loc.*.—Common under boards and rubbish, etc., on cultivated land. South Australia: Glen Osmond, May 1932 (one specimen); Adelaide, July 1942 (many female specimens). Western Australia: Perth, February 1932 (one specimen).

*Remarks*.—As only Berlese's brief description and figures are available to me, the identification of my material with this species is somewhat uncertain. It closely resembles it in the ventral and dorsal shields and the mandibles, but appears to differ in that the arms of the fish-tail portion of the epistome are not anteriorly ciliated as Berlese's figures.

Genus *GEHOLASPIS* Berlese 1918

Redia 1918, 13, fasc. 1, 145.

As in *Macrocheles* but with five pairs of setae on the ventrianal shield besides the circumanal setae.

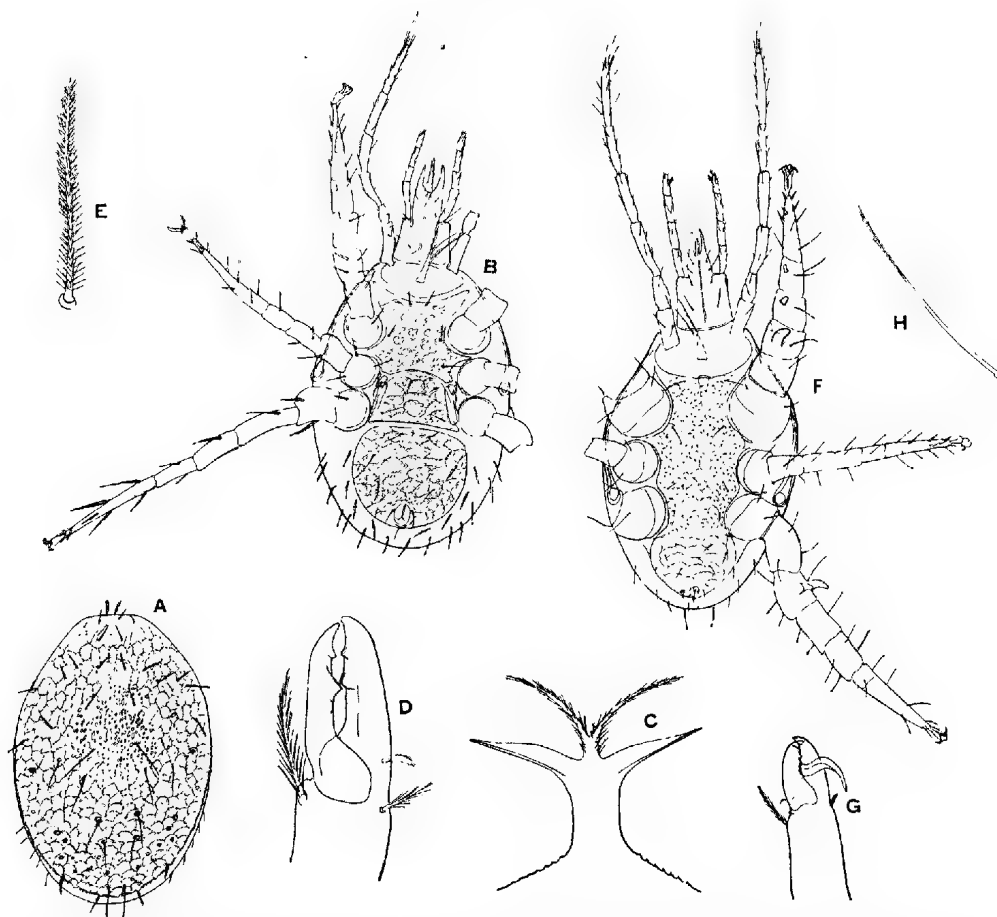


Fig. 18, A-E *Nothrholaspis* ?*montivagus* Berl.: A, dorsal view ♂; B, ventral view ♀; C, epistome; D, mandible; E, lateral dorsal seta. F-H *Geholaspis* sp.: F, ventral view ♂; G, mandible; H, dorsal seta from posterior end.

*GEHOLASPIS* sp.

(Fig. 18, F-H)

*Male*.—Length 900  $\mu$ , width 420  $\mu$ . Sternal, epigynial and ventrianal shields all coalesced, sterno-epigynial portion with four pairs of setae and irregularly finely rugose, ventrianal portion with five pairs of setae besides the adanal and postanal setae. Dorsal shield and epistome unobservable owing to damage, but dorsal setae mostly simply, about 30  $\mu$  long, with posteriorly a pair, apically ciliated and about 40-50  $\mu$  long (fig. 18, A). Mandibles as in fig. 18, G, fixed chela with stout bent process. Legs, II and IV much stouter than I and III, I 580  $\mu$  long, II 500  $\mu$ , III 420  $\mu$ , IV 850  $\mu$ ; leg II with stout, short, curved process on femur, and a smaller one on genu and on tibia, leg IV with a pair of processes on femur.

*Loc.*—A single male specimen taken by Mr. S. L. Allman from a dahlia bulb at Bathurst, New South Wales, November 1932.

*Remarks*.—Owing to having only a single male and because the preparation became seriously damaged during study, it is not possible at present to place this species other than in the genus.



Genus *Euepicrius* nov.

Broadly rounded. Dorsum with a narrow suture beyond the middle. Anterior legs long, without ambulacra or claws in both sexes. Palpal tarsus with three-pronged fork. Epistome triangular with median short broad triangular tooth and laterally three to four small short teeth. Mandibles of  $\delta$  with long slender calcar process on fixed chela. Legs II of  $\delta$  armed. Venter: no prae-endopodal shield; sternum with four pairs of setae and three pairs of pores; epigynial free with rounded anterior and straight posterior margin, with one pair of setae; ventrianal shield occupying the whole of the venter and only indistinctly separated from the parapodial shields. Peritreme long and corrugated. Type *Euepicrius filamentosus* n. sp.

*Euepicrius filamentosus* n. sp.

(Fig. 19, A-J)

*Description* Broadly rounded species, with the dorsal shields strongly rugose, and strongly chitinated, yellow to brown in colour. Length.  $\varnothing$  580  $\mu$ ,  $\sigma$  500  $\mu$ ; width  $\varnothing$  420  $\mu$ ,  $\sigma$  420  $\mu$ . Dorsally with long filamentous setae (fig. 19, A) reaching ca. 100-120  $\mu$ , posteriorly with a pair of stout ciliate setae 70  $\mu$ . Legs, I longer than body, antenniform,  $\varnothing$  750  $\mu$  long,  $\sigma$  720  $\mu$ , tarsus without claws; II  $\varnothing$  500  $\mu$ ,  $\sigma$  350  $\mu$ , femur with long calcar process; III  $\varnothing$  480  $\mu$ ,  $\sigma$  350  $\mu$ ; IV  $\varnothing$  580  $\mu$ ,  $\sigma$  550  $\mu$ . Epistome (fig. 19, E, F) similar in both sexes. Labial

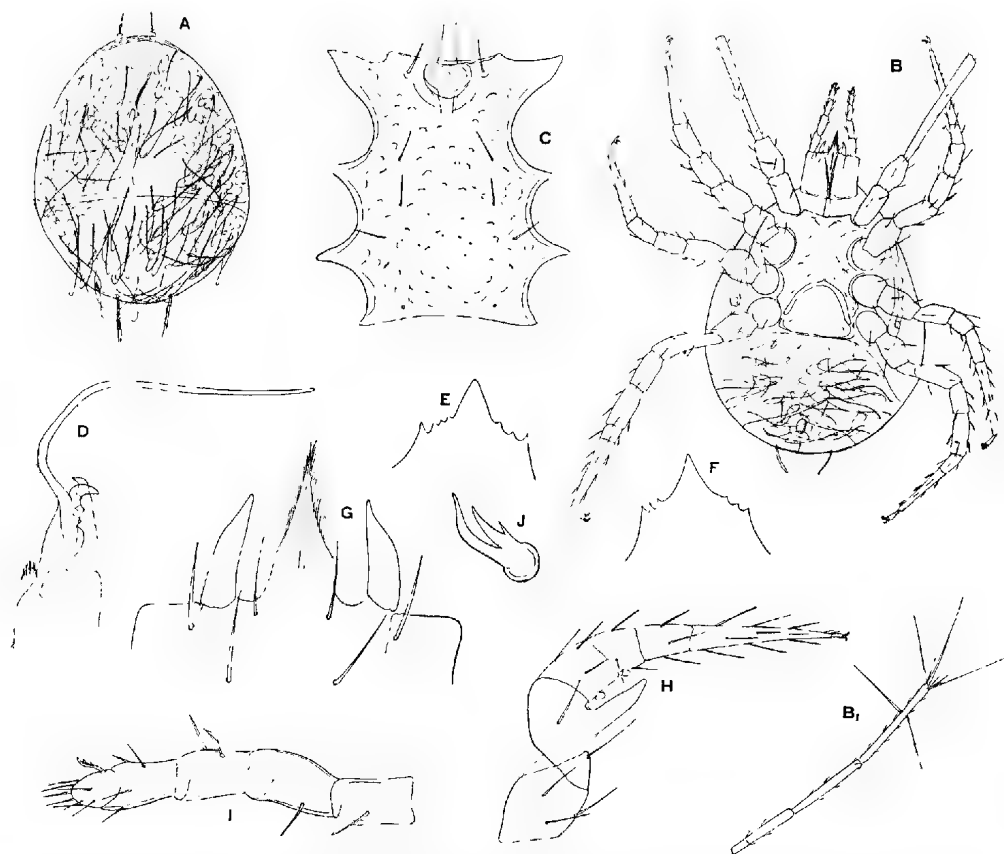


Fig. 19, A-J *Euepicrius filamentosus* n.g. et n.sp.: A, dorsal view  $\varnothing$ ; B, ventral view of  $\varnothing$ ; B1, end segments of leg I; C,  $\sigma$  sternal shield; D,  $\sigma$  mandible; E, epistome  $\sigma$ ; F, epistome  $\varnothing$ ; G, labial cornicle; H,  $\sigma$  leg II; I, palp; J, fork of tarsus of palp.

cornicles as in fig. 19, G. Palpi with sensory spathulate seta on genu. Mandibles as in fig. 18, D, fixed chela of ♂ with a long, slender bent process.

Venter: ♀ (fig. 19, B) no prae-endopodal shields, sternal shield with four pairs of short setae, the three anterior pairs situated well towards the medial line, and representing the fused jugular, coxal and metasternal shields; fourth endopodal shield not visible; genital shield round anteriorly, straight posteriorly with one pair of setae; ventrianal shield large, occupying whole of venter and separated from the parapodial shields only by a fine oblique line: ♂ sternal shield as in fig. 19, C. Ventrianal shield in both sexes with long filamentous setae.

*Loc.*—South Australia, in moss, Glen Osmond, June 1933, July 1935; Long Gully, August 1938. Also one female from Wainamaku, New Zealand, October 1938 (E. D. P.).

*Remarks*—The generic name is given on account of the, at first glance, superficial likeness to the genus *Epicrius*, especially in the long anterior legs without claws. In the presence of a distinct peritreme, three-pronged palpal fork and the structure of the ventral shields it must be placed in the family Macrochelidae.

# **SOME NEMATODES FROM AUSTRALIAN FROGS**

By T. HARVEY JOHNSTON and E. R. SIMPSON, University of Adelaide

## **Summary**

*Oswaldocruzia limnodynastes* n. sp.

From intestine, *Limnodynastes dorsalis*, Adelaide.<sup>(1)</sup> Female, 6·7 to 9·5 mm. long; breadth ·12 mm. for worms 6·7 to 7 mm. long, ·15 mm. for worms 9·5 mm. long. Male, 3·8 mm. long, ·1 mm. broad. Body filiform, tapering at both ends in female, but tail truncate in male; tail of female ending in spine 18  $\mu$  long. Cuticle with about 24 longitudinal striations (as in *O. malayana*) visible under oil immersion together with much finer longitudinal markings between the larger. Lateral membranous wings absent; cephalic cuticle inflated, with fine transverse striations, inflated region broader anteriorly but tapering posteriorly to end at ·1 mm. from the head end of a worm 6·7 mm. long. Transverse striations not observed caudad of inflated area. Four minute submedian head-papillae; cervical papillae absent.

## SOME NEMATODES FROM AUSTRALIAN FROGS

By T. HARVEY JOHNSTON and E. R. SIMPSON, University of Adelaide

[Read 10 September 1942]

*Oswaldocruzia limnodynastes* n. sp.

(Fig. 1-4)

From intestine, *Limnodynastes dorsalis*, Adelaide.<sup>(1)</sup> Female, 6.7 to 9.5 mm. long; breadth .12 mm. for worms 6.7 to 7 mm. long, .15 mm. for worms 9.5 mm. long. Male, 3.8 mm. long, .1 mm. broad. Body filiform, tapering at both ends in female, but tail truncate in male; tail of female ending in spine 18  $\mu$  long. Cuticle with about 24 longitudinal striations (as in *O. malayana*) visible under oil immersion together with much finer longitudinal markings between the larger. Lateral membranous wings absent; cephalic cuticle inflated, with fine transverse striations, inflated region broader anteriorly but tapering posteriorly to end at .1 mm. from the head end of a worm 6.7 mm. long. Transverse striations not observed caudad of inflated area. Four minute submedian head-papillae; cervical papillae absent.

Mouth with three insignificant lips devoid of papillae or special chitination. Oesophagus .43 mm. long, 18  $\mu$  broad in region of nerve ring in female 6.7 mm. long; cylindrical anteriorly, posterior portion conical. Intestine dilated just in front of conical rectum. Rectal glands, probably three, at sides of narrow junction of intestine and rectum. Anus .2 mm. from tip of tail in female 8.4 mm. long.

Nerve ring inconspicuous, .18 mm. from anterior end of worm 6.7 mm. long, in vicinity of excretory aperture. Latter on very slight elevation, .27 mm. from head end of female 6.7 mm. long. Excretory sac 90  $\mu$  long, 45  $\mu$  broad, opening about 25  $\mu$  from its anterior end into small tube leading to pore. The Y-shaped gland of *O. insulae* Morishita (1926) and the corresponding organ (Travassos 1917) in *O. leidy* appear to be much more ornate than the simple sac of *O. limnodynastes*.

*Female*—Ovaries arising anterior to genital pore; divergent, one extending anteriorly almost to pharynx and then returning as oviduct, posterior ovary travelling caudad to region of rectum to become the oviduct which bends forwards as uterus. Vulva a transverse slit, 40  $\mu$  long, in anterior part of posterior third of body, with slightly protruding lips. Vagina thin-walled, divergent, each arm 40  $\mu$  long and continuous with short ovejector. Latter of two portions, proximal part puckered and corresponding to the funnel of *O. leidy* as described by Steiner (1924), distal part with faint longitudinal striations suggesting muscle fibres; distal portion leading through four valves with longitudinal striations into vagina. Valvular region with small lumen and very thick walls, area just behind valves slightly bulbous and with faint transverse striations suggestive of sphincter fibres; on outer side of bulb a row of large cells with distinct nuclei, these cells being probably secretory and representing the "varnish gland" of *O. leidy* (Steiner 1924) and *O. pipiens* (Walton 1929). A vulvar dilator muscle was seen in the same position and with the same relations as that of *O. leidy*. Eggs 36  $\mu$  by 25  $\mu$ , in morula stage on arrival in uteri. Oviduct walls more granular at junction with uterus, this part perhaps serving as a shell gland.

*Male*—Testis enlarged posteriorly before entering vesicula seminalis; ejaculatory duct and rectum forming partly chitinated tube opening at base of genital cone. Spicules short, 95  $\mu$  in length, shape difficult to determine because of

<sup>(1)</sup> *O. limnodynastes* has also been identified from material collected from *Hyla aurea* from Sydney and Melbourne.

presence of spines and projections; distal portion apparently ending in three spines, one strongly chitinized and forming base of somewhat trowel-shaped spicule, the other two spines supporting its sides; proximal part characteristic, forming short handle of the trowel and provided with median spine. Accessory piece slightly curved, slipper-shaped,  $45\ \mu$  long. Gubernaculum absent.

Bursa with two lateral and a small median dorsal lobe. Latter supported by dorsal ray ending in four branches, the arrangement resembling that of *O. pipiens* (Walton 1929). Each lateral lobe with six rays; ventro-ventral and latero-ventral close together and reaching edge of bursa; externo-lateral slightly broader than the others and curved ventrally; median and postero-lateral rays together and reaching edge of bursa; externo-dorsal arising from base of dorsal ray. Three pairs minute preanal papillae. Genital cone chitinized,  $12\ \mu$  long.

Our specimens fall within the genus *Oswaldocruzia* Trav. 1917, as emended by Morishita (1926), because of the filiform body, expanded head, transversely striated cuticle, form of bursa, ventral rays nearly equal and adjacent, medio- and postero-lateral rays parallel and curving dorsad, externo-dorsal ray arising from the base of the thick, straight dorsal ray which divides into four branches at its extremity, spicules equal similar and branched and absence of gubernaculum and prebursal papillae. The presence of an accessory piece is not usually mentioned by authors, though Baylis (1933) stated that in *O. malayana* it was narrow and canoe-shaped but was not heavily chitinized. Travassos (1937) transferred the latter species to *Trichoskrjabinia*. The latter author reviewed the genus *Oswaldocruzia* (1937) in his monograph of the Trichostrongylidae.

### *Spiroonoura hylae* n. sp.

(Fig. 5-7)

From intestine, *Hyla aurea*, Sydney. Slender elongate worms; female 12-18 mm. long by  $\cdot 45$  mm.; male 13-13.5 mm. by  $\cdot 33$ - $\cdot 38$  mm. Mouth with three lips, each with two papillae; pulp of each papilla expanding just below surface as though to subtend two, instead of one, papillae, the condition thus being intermediate between that of *Spiroonoura* which has two inner and two outer papillae on each lip, and that of *Zanclophorus* which possesses two papillae on each lip.

Buccal cavity with three chitinous plaques similar to those described by Seurat (1918) for *S. lambdiensis*; two horse-shoe-shaped cuticular supports at each corner of cavity. Short anterior gullet or pharynx; oesophagus long, 1.84-2.1 mm. in male; oesophageal bulb differentiated into anterior somewhat pyriform portion and posterior spherical region, separated by deep constriction. Several valves at oesophageo-intestinal aperture. Intestine slightly dilated at anterior end; rectum narrow with chitinized walls and receiving rectal glands; large anal dilator muscle. Simple sac-like excretory vesicle with narrow duct opening on mid-ventral surface,  $\cdot 67$  mm. from anterior end in male specimen 13 mm. long. Nerve ring  $\cdot 4$ - $\cdot 43$  mm. from anterior end in female,  $\cdot 37$  mm. in male.

*Female* -Vulva near commencement of posterior third of body length; lips protruding slightly. Vagina lined by large columnar cells; sphincter near vulva; vagina passing forwards, widening somewhat just before junction with the two uteri. Latter lined by flattened cells; opposed, each uterus bent on itself in a number of U-shaped loops in anterior and posterior parts of body; circular muscle at junction of uterus and oviduct. Each ovary forming long loop in anterior region of body, anterior ovary and uterus remaining there, the other ovary proceeding a short distance caudad from vulva to join oviduct, the posterior uterus making its way forwards to enter the vagina anteriorly to the vulva. Both oviducts U-shaped. Eggs 54 by  $43\ \mu$ , little development before being laid.

*Male*—Testis arising in posterior half of body, extending forwards nearly to oesophagus before bending back to become vas deferens. Preanal sucker just in front of oblique muscles of tail. Spicules 2 mm. long, curved, similar, flattened laterally, much broader at distal end, ventral side with two thickened ridges that are more heavily chitinized at the free end of the spicule. Accessory piece shaped like an open trough with the four corners prolonged into spines. Papillae ten pairs including four preanal pairs; single median pre-anal papilla.

The species agrees with *Spironoura* in having a pharynx and oblique muscle; in the characteristic preanal sucker; and in the absence of cuticular fringes on the lips. It differs from *Spironoura* but agrees with *Zanclophorus* in the number of papillae on each lip, the presence of horse-shoe-shaped cuticular ridges at the corners of the mouth, the presence of cuticular plaques in the vestibule, the length of the spicules, and the presence of a fairly well developed accessory piece. These facts suggest that *Zanclophorus* should be regarded as a synonym of *Spironoura* whose generic diagnosis would then require some emendation.

### ***Cosmocera limnodynastes* n. sp.**

(Fig. 13-15)

Small worms from intestine of *Limnodynastes dorsalis*, Adelaide. Female 4.25 mm. long, 485  $\mu$  broad; male 1.6 mm. long, 185  $\mu$  broad. Mouth with three insignificant lips, dorsal less prominent than ventro-laterals; each lip with two small papillae. Ventral wall of pharynx prolonged between ventro-lateral lips to resemble a fourth lip.

Mouth opening into small vestibule about 15  $\mu$  long. Oesophagus simple, straight, dilated posteriorly to form bulb with valvular apparatus in centre. Oesophagus and bulb 430  $\mu$  long in female; 310  $\mu$  long and 27  $\mu$  broad in male; bulb 53  $\mu$  long and 59  $\mu$  broad in male; its opening into the anterior swollen part of intestine guarded by valves. Rectum lined with chitin; three large rectal glands present.

Nerve ring 8.75  $\mu$  broad, 149  $\mu$  and 162  $\mu$  from anterior end in male and female respectively. Excretory pore on same level as oesophageal bulb; 431  $\mu$  from anterior end in female, 306  $\mu$  in male. Two longitudinal excretory canals joining ventrally to form terminal vesicle opening on slight prominence on mid-ventral surface; terminal region of canals and the vesicle itself surrounded by group of large cells. Excretory pore with circular and longitudinal muscle fibres.

*Female*—Ovaries arising in anterior part of body and passing forwards to about 300  $\mu$  from anterior end, then turning back to travel posteriorly. One enters its uterus in region of vulva; the other forming with the posterior uterus a U-shaped loop near the rectum. Uteri large, with eggs in all stages of development; coiled embryo present in the more mature eggs. Vagina 250  $\mu$  long; 2.1 mm. from anterior end of a worm 3.8 mm. long. Eggs 144  $\mu$  long, 94  $\mu$  broad. In their general outlines the genitalia of the female resemble those of *C. commutata* (Travassos 1931).

*Male*—Tail curved ventrally, ending in short spine; numerous papillae and plectanes. Latter in two rows of five each, preanal in position; also a single median plectane just anterior to cloacal opening; each plectane strengthened by chitinous tooth and bearing rosette consisting of ring of small teeth at its extremity. Row of papillae on each side of plectanes; five pairs of papillae near spicule, two of these surrounding anus. Post-anal papillae arranged in two series, one series on either side of mid-ventral line, and the other irregularly scattered over the surface; size of papillae decreasing as they proceed caudad. Gubernaculum large, 0.11 mm. long, shaped like a spicule with a grooved ventral surface in which spicules glide. In both the specimens examined it protruded from the surface of the body and its free end was pointed. Walls of cloaca chitinized and

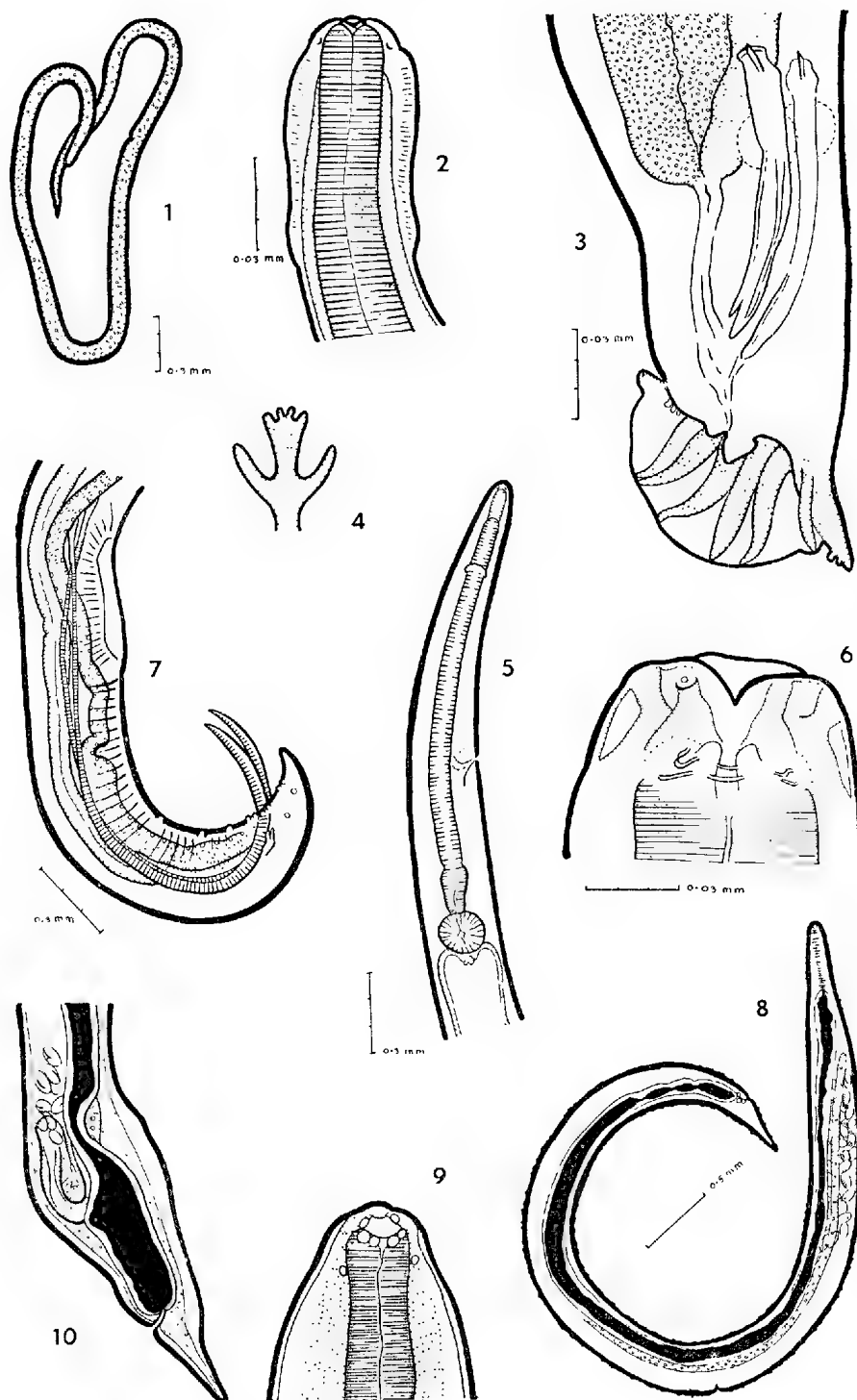


Fig. 1-10

Fig. 1-4, *Oswaldocruzia limnodynastes*: 1, female; 2, head (to same scale as fig. 3); 3, tail of male; 4, dorsal ray. Fig. 5-7, *Spironoura hylae*: 5, anterior end; 6, head; 7, tail of male. Fig. 8-10, *Rhabdias hylae*: 8, worm from lung; 9, head; 10, tail.

especially thickened just below anus, to constitute an accessory piece. Spicules slender, resembling simple curved rods;  $2.4\ \mu$  broad; length not ascertained with certainty but lying somewhere between  $50\ \mu$  and  $75\ \mu$ . In general configuration, gubernaculum and spicules resembling those of *C. commutata* as figured by Travassos (1931).

***Cosmocerca australiensis* n. sp.**

(Fig. 16)

Females from intestine of *Limnodynastes dorsalis*, from the vicinity of Adelaide. Since no males are available, classification is difficult, the distinctions between sub-families being based upon characters possessed by the male. The specimens belong to the Cosmocercinae (Railliet 1916) and most closely resemble members of the genus *Cosmocerca*. They differ from the allied *Cosmocercella* in the extreme anterior position of the vulva and in the absence of typical papillae, only two labial papillae being present in this species; and from *Aplectana* in the anterior position of the vulva and in the absence of two divisions in the oesophagus. They are accordingly grouped provisionally under *Cosmocerca*.

Worms short,  $7.5 - 9$  mm. long,  $380 - 480\ \mu$  broad. Cuticle transversely striated. Tail ending in long spine about  $1.0$  mm. in length. Oesophagus (including bulb)  $353\ \mu$  long,  $47\ \mu$  broad; slightly dilated just anterior to, and constricted just before entering, bulb; latter  $99\ \mu$  long,  $126\ \mu$  broad, with valvular apparatus in centre; its opening into intestine guarded by valves. Intestine simple, anterior part slightly swollen. A number of rectal glands; well-developed post-anal dilator muscle.

Terminal excretory vesicle circular, supported by chitinous thickenings; opening immediately anterior to vulva. Nerve ring  $150\ \mu$  from the anterior end.

Ovaries divergent, arising near mid-body; posterior ovary proceeding caudad, to give rise to oviduct; anterior ovary passing forwards into vicinity of vagina to become convoluted, its oviduct proceeding caudad to region of rectum, whence, turning back again, it runs alongside the other oviduct. The two travel cephalad and open into the large uterus, which contains eggs in the morula stage. Vagina divided into proximal glandular and distal muscular portion; vulva at  $573\ \mu$  from anterior end. Eggs ellipsoidal,  $137\ \mu$  by  $36\ \mu$ .

***Cosmocerca propinqua* n. sp.**

(Fig. 11-12)

Females from intestine of *Limnodynastes dorsalis*, Adelaide. It is closely allied to *C. australiensis*, and differs from it in the following characters:

Worms shorter, measuring  $5$  mm. long,  $369\ \mu$  broad; oesophagus  $480\ \mu$  long,  $43\ \mu$  broad, its bulb  $108\ \mu$  long,  $126\ \mu$  broad; nerve ring  $126\ \mu$  from anterior end. Excretory vesicle oblong; chitinous rim surrounding the excretory pore.

Ovaries arising near mid-body and passing posteriorly where they enter the oviducts; latter proceeding cephalad, becoming convoluted and then, passing caudad, opening into uterus posteriorly. Uterus extending from region of ovaries to beginning of tail; anteriorly passing into thick-walled vagina. Vulva forming marked projection on ventral surface of body,  $290\ \mu$  from anterior end, well in front of oesophageal bulb, and in this feature especially differing markedly from *C. australiensis*.

***Rhabdias hylae* n. sp.**

(Fig. 8-10)

From lung, *Hyla aurea* from Sydney (type host and locality) and from Melbourne; *H. caerulea* from Brisbane; and *Limnodynastes tasmaniensis* from Adelaide. The following account is based on material from *H. aurea* from Sydney.

Length  $6.5-7.8$  mm.; breadth  $.34-.37$  mm. Cuticle with faint longitudinal



striations and with annular ridges at regular intervals. Excretory pore probably immediately behind nerve ring. Mouth terminal with six very low, scarcely discernible lips. Buccal capsule  $11\ \mu$  long. Oesophagus  $\cdot 38\text{--}\cdot 46$  mm. long, maximum breadth  $36\text{--}46\ \mu$  (near nerve ring), muscular, slightly swollen just in front of nerve ring, club-shaped toward posterior end. At junction of buccal

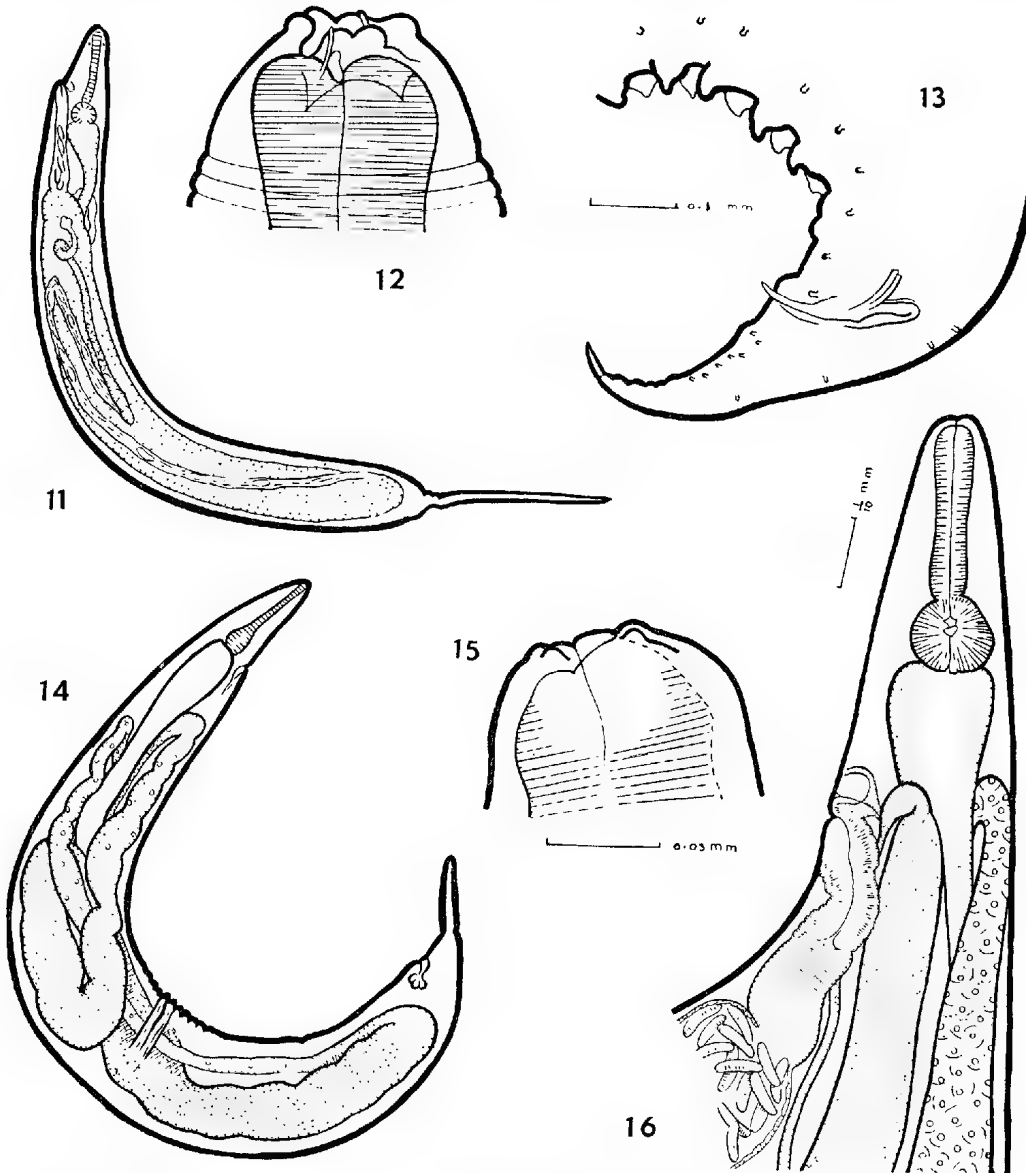


Fig. 11-16

Fig. 11-12, *Cosmocerca propinqua*. Fig. 13-15, *Cosmocerca limnodynastes*. Fig. 16, *Cosmocerca australiensis*.

capsule and oesophagus eight tooth-like structures seen in some specimens. Intestine dark brown; constricted near its posterior end, then swollen, then constricted suddenly into narrow rectum with well-chitinated wall. Anus at  $\cdot 34\text{--}\cdot 4$  mm. from posterior end. Nerve ring at  $\cdot 17\text{--}\cdot 18$  mm. from anterior end; a more anterior ring at about  $36\ \mu$  from head end.

Vulva at 3.25-3.85 mm. from anterior end, *i.e.*, almost at mid-length of body, immediately in front of it in measured specimens. Ovaries long, divergent, extending for greater part of length of body; bending back on themselves to lead into V-shaped receptaculum with thickened walls and then into widened uterus. The two uteri unite close to vulva. Eggs elliptical, 10 by 55  $\mu$ , with broadly rounded ends; with advanced embryos. Larvae common in lungs and digestive tract, especially rectum.

The occurrence of lung worms in Australian frogs has already been recorded. Haswell (1891) referred to the presence of *Rhabdonema* sp. in *Hyla aurea* in New South Wales. T. H. Johnston (1916) mentioned that *Rhabdonema* occurred in *Hyla caerulea* in Brisbane, and that *Rhabdias* sp. (1938, 151) was found in *H. aurea* in New South Wales and in Victoria. S. J. Johnston (1912) reported that lung worms occurred in the following species of frogs in New South Wales: *Hyla aurea*, *H. peroni*, *Limnodynastes peroni*, and *L. tasmaniensis*. Since we have recognised *Rhabdias hylae* from species of *Hyla* ranging from Brisbane to Melbourne as well as in *L. tasmaniensis* in Adelaide, it is very probable that the lung worms referred to by S. J. Johnston as occurring in frogs from the coastal region of New South Wales belong to *R. hylae*, and we have accordingly listed them under that name.

Chu (1936) gave a detailed account of his studies on the life history of *R. fuscovenosa* var. *catanensis*, a reptilian parasite in U.S.A., and indicated that eggs from the parasitic phase could undergo direct development or could give rise to a free-living sexual generation such as occurs in most species of *Rhabdias* from frogs so far investigated. He stated (1936, 140) that both types of life cycle were known to occur in *R. ranae*. One of us (T. H. J., 1931, 151) reported that the lung worm of *Hyla aurea* produced a free-living sexual generation. Travassos (1930) suggested the subdivision of *Rhabdias* and allocated the known species. Our form belongs to *Rhabdias* as restricted by him.

#### PHYSALOPTERA CONFUSA Johnston and Mawson

This nematode, in its adult stage, is common in the tiger snake, *Notechis scutatus*, in the Murray River districts of South Australia, where its presence was reported by Johnston and Mawson (1942, 90-91), who recorded finding the encysted larval stage in the viscera of the following frogs: *Limnodynastes dorsalis* (including its variety *dumerili*) from the Adelaide district and from the Tailm Bend swamps, S. Aust.; *Hyla peroni* from the latter locality; and *Hyla aurea* from Sydney, New South Wales. We now record the finding of these larvae in their characteristic dark brown cysts in the submucosa of the stomach of *Limnodynastes tasmaniensis* and *L. dorsalis* from Sydney, and from *Hyla caerulea* from Brisbane. These records were not unexpected, since Johnston and Mawson (1942 a, 115) have recently reported the presence of the adult stage in the black snake, *Pseudechis porphyriacus* in the coastal region of New South Wales. Frogs form an important part of the food supply of this snake, as well as of the tiger snake.

Acknowledgment is made of assistance afforded by the Commonwealth Research Grant to the University of Adelaide.

#### HOST LIST

- HYLA AUREA—*Rhabdias hylae* (Sydney; Melbourne); *Spirogonia hylae* (Sydney); *Oswaldocruzia limnodynastes* (Sydney; Melbourne).  
 HYLA PERONI—*Rhabdias hylae* (coastal region, New South Wales).  
 HYLA CAERULEA—*Rhabdias hylae* (Brisbane); *Physaloptera confusa*, encysted larvae (Brisbane).

LIMNODYNASTES DORSALIS—*Rhabdias hylae* (New South Wales); *Oswaldocruzia limnodynastes* (Adelaide); *Cosmocerca limnodynastes* (Adelaide); *C. australiensis* (Adelaide); *C. propinqua* (Adelaide); *Physaloptera confusa* encysted larvae (Sydney).

LIMNODYNASTES PERONI—*Rhabdias hylae* (New South Wales).

LIMNODYNASTES TASMANIENSIS *Rhabdias hylae* (Adelaide; New South Wales); *Physaloptera confusa*, encysted larvae (Sydney).

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# **FURTHER NOTES ON THE MORPHOLOGY OF THE INSECT HEAD**

By J. W. EVANS

## **Summary**

In a recent paper (Evans 1942, a), in which a description was given of a larval Mecopteron, thought to be the larva of *Nannochorista* sp., a figure was included of a generalized insect head. The attempted reconstruction was based on the sutures of the head of the larva which formed the subject of the paper and on the information given by Imms (1925, 20).

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[Read 10 September 1942]

In a recent paper (Evans 1942, a), in which a description was given of a larval Mecopteron, thought to be the larva of *Nannochorista* sp., a figure was included of a generalized insect head. The attempted reconstruction was based on the sutures of the head of the larva which formed the subject of the paper and on the information given by Innis (1925, 20).

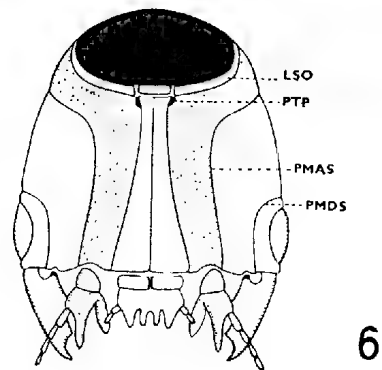
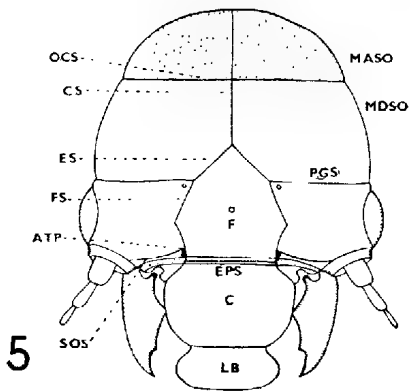
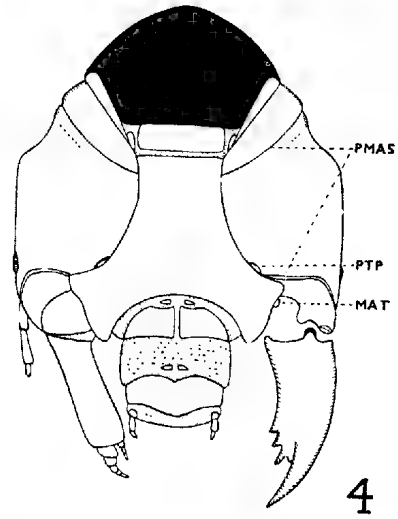
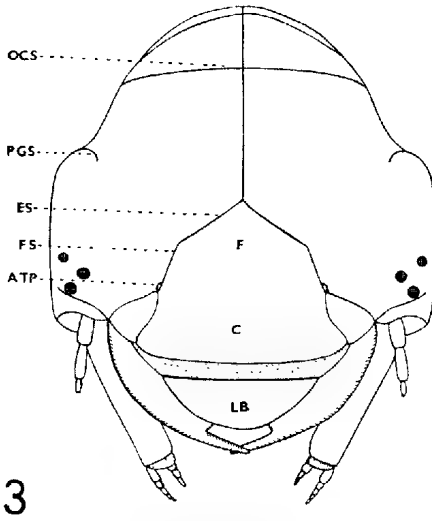
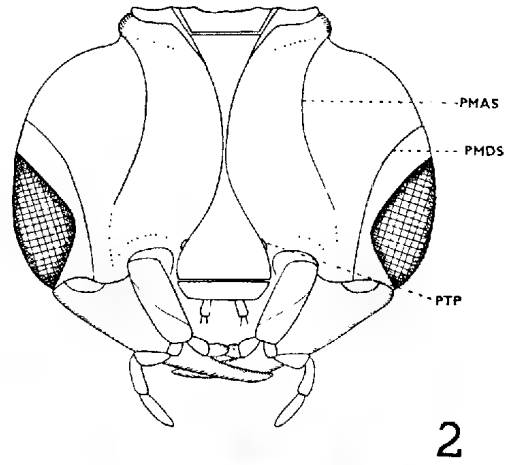
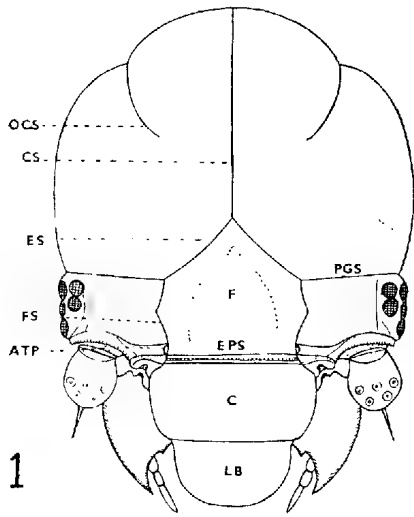
Shortly after the publication of this paper, a copy was received of one by Ferris (1942), entitled "Some observations on the Head of Insects." In this stimulating work, which merits the close attention of everyone interested in insect morphology, the author rejects Snodgrass' (1935) contention that the majority of the various sutures which appear on the insect head capsule have no relation to original metamerism. Commencing with the head of a Symphylan, he proceeds to show how certain sutures present in this form, in particular the suture between the mandibular and antennal segments, are retained in the heads of insects. Finally, he arrives at the conclusion that "The various sutures on the insect head have a definite relation to, and are an expression of, primitive segmentation." At the end of the paper is given a reconstruction of a type of a generalized head as visualized by the author. This type differs very considerably from the one proposed earlier by Snodgrass.

A cursory study of Ferris' contribution made it clear that my own attempted reconstruction was based on certain misconceptions. At the same time Ferris' views were not found to be entirely satisfying, nor, in spite of his claims to have achieved consistency, entirely consistent. It was apparent, for instance, that he had made the identical mistake, for the perpetration of which he so severely castigates other authors—the mistake in question being the calling of the same suture by different names in different figures. Further study revealed the reasons for the discrepancies observed, and it is the purpose of this paper to suggest an alternative and, it is believed, a more consistent explanation for certain of the points raised by Ferris. At the same time, full acknowledgment is made of the very noteworthy and considerable addition to our knowledge of the insect head which he has made available. The alterations in interpretation suggested in the paragraphs that follow are an attempt to change one brick for another rather than to pull down the whole structure.

## EXPLANATION OF FIG. 1-6

Fig. 1, head of a larval Mecopteron (*Nannochorista* sp. ?) in facial aspect; fig. 2, head of an adult Staphylinid Beetle, in ventral aspect; fig. 3, head of a nymph of *Archichauliodes dubittatus* (Neuroptera, Corydalidae), in facial aspect; fig. 4, head of a nymph of *A. dubittatus* in ventral aspect; fig. 5, head of a generalized insect in facial aspect; fig. 6, head of a generalized insect in ventral aspect.

*Abbreviations*—atp, anterior tentorial pit; c, clypeus; cs, coronal suture; eps, epistomal suture; es, epicranial suture; f, frons; fs, frontal suture; lh, labrum; lso, labial somite; maso, maxillary somite; mdso, mandibular somite; ocs, occipital suture; pgs, postgenal suture; pmas, premaxillary suture; pmbs, premandibular suture; ptp, posterior tentorial pit; sos, subocular suture.



## DISCUSSION

In the head of the Symphylan *ScutigereUa immaculata* (Newport) Ferris has traced the full course of a suture which lies between the mandibular and antennal segments. This suture, which he terms the great suture, and which is not developed in such local Symphylans as have been examined, arises from just anterior to the primary articulation of the mandible. It passes behind the post-antennal organ crosses the head above the antennae, and then, together with the corresponding suture from the other side of the head forms an inverted V on the face of the head. The V-suture, called by Ferris the postfrontal suture, is homologised with the frontal, postfrontal or epicranial sutures of various authors. That part of the rest of the great suture which is on the face of the head is termed the temporal suture, and the posterior part the premandibular suture.

It is agreed that the median facial V of the great suture of *ScutigereUa* is homologous with the suture of insect heads called by Ferris the postfrontal, and in the present paper, the epicranial suture. It is questioned whether a single one of the sutures of the insect head, indicated as temporal and premandibular sutures in his figures, is homologous with the temporal and premandibular sutures of *ScutigereUa*. Instead, it is suggested that the sutures called postgenal sutures in fig. 1 (a Mecopteron larva) and in fig. 2 (a Corydalid larva) are homologous with the temporal sutures of *ScutigereUa*, and that the sutures labelled premandibular sutures in fig. 2 (an adult Staphylinid beetle<sup>(1)</sup>) are homologous with the premandibular sutures of *ScutigereUa*.

If this interpretation is accepted, then that part of the head lying between the postgenal and occipital sutures on the face of the head belongs to the mandibular segment. The part of the dorsal surface of the head posterior to the occipital suture consequently belongs to the maxillary segment. In certain insects the occipital suture extends on to the ventral surface of the head, where it may remain distinct (fig. 2), or lose its identity for part of its course (fig. 4). This suture, which is called the premaxillary suture in fig. 2, 4 and 6, is identical with the one termed the premandibular suture in the majority of Ferris' figures, whilst the occipital suture is called by him either the temporal or temporal + postfrontal suture.

It follows that, as a result of these inconsistencies, others must be expected. Thus Applegarth (1939), who figured the head of the larva of the Mecopteron *Apterobittacus apterus*, called a transverse fold lying between the pits of the anterior arms of the tentorium, the epistomal suture. In view of the position of the fold between the pits, it is hard to understand how any other interpretation could be possible, and that it was most certainly correct is shown by the presence of a well-developed epistomal suture in an identical position in fig. 1. Yet Ferris is forced to consider that Applegarth made an error of interpretation, and in his fig. 21, illustrating the head of a Corydalid larva, in which the epistomal suture is not developed, he terms a suture which is most certainly his postfrontal suture (the epicranial suture of the present paper) the clypeofrontal suture! On the opposite page, in his fig. 22, illustrating the head of a Neuropteron belonging to the family Polystoechotidae, the identical suture is labelled, here correctly, the postfrontal suture.

A further attempt is made in fig. 5 and 6 to reconstruct the head of a generalized insect. It will be noticed that the head figured is prognathous though the reconstructions of both Ferris and Snodgrass are of hypognathous insects. A prognathous form has been chosen because it would seem that insects with such heads retain more primitive characteristics than ones with hypognathous heads.

<sup>(1)</sup> The identity of the beetle figured is unknown. Two specimens of the particular species were discovered in the collection of the Tasmanian Department of Agriculture, bearing the label "Brazil."

## LABIAL SEGMENT

In fig. 6 the postmentum is represented as medially divided, not merely because it must have been so at one time, but because it actually is in the head of the larva, the dorsal surface of which is illustrated in fig. 1. The small rectangular plate lying at the posterior apex of the submentum is called by Ferris the jugular sclerite. It is hard to resist the conclusion that this represents the sternum of the labial segment. The tergum of the labial segment seldom, if ever, extends on to the dorsal surface of the head, and it is believed that the narrow band posterior to the occiput in the larva of *Archichauliodes* (fig. 3) is of an apodemal nature rather than part of the labial somite.

## PREMANDIBULAR AND POSTGENAL SUTURES

True premandibular sutures are rarely retained in insects, likewise postgenal sutures. The latter have already (Evans, 1942, a) been shown to occur in certain Homoptera, Dermaptera and in Perlid nymphs.

## POSITION OF THE OCELLI

Ferris asserts that he has seen no insect in which the median ocellus lies between the arms of the frontal sutures as shown in Snodgrass' reconstruction of a generalized insect. Yet in the Psyllid *Paurocephala magnifrons* figured in Crawford (1914), and in fact in all Psyllids, and in certain Fulgoroids, such a condition exists. The explanation given previously (Evans, 1942, a) to account for the apparent position of the lateral ocelli, either anterior to or posterior to the frontal sutures, is as follows: When all three ocelli lie anterior to the transverse suture, as in certain Dermaptera, epicranial and postgenal but not frontal sutures are retained. When, on the other hand, postgenal sutures are lost and epicranial and frontal sutures retained, the lateral ocelli are separated from the median ocellus. The latter condition occurs in such Fulgoroids as retain a median ocellus. In Psyllids, postgenal, as well as frontal and epicranial sutures, are present (Evans, 1942, b).

## SUBOCULAR SUTURES

Attention has been drawn on a former occasion (Evans, 1942, a) to the suture called the subocular suture in fig. 5. The identical suture, which may be seen also in fig. 1 and 3, is not homologous with the subocular suture of Snodgrass. It is suggested that this suture separates the premandibular segment, of which the genae, but not the eyes, may be part, from the antennal segment. A search has not been made to determine whether it is retained in several, or in only a few, insect types. It is, however, retained in some, and is for instance, homologous with the suture lying just posterior to the antennae in the nymphs of *Tartessus* (Jassoidea), illustrated in Evans, 1941. In the majority of leaf-hoppers the suture is replaced by the post-antennal ledge.

## EPISTOMAL SUTURE

Agreement is expressed with Ferris that the epistomal suture, termed by him the clypeo-frontal suture, represents the segmental line between the antennal and pre-antennal segments. Though lost in *Archichauliodes* (fig. 3), its former position may be determined by the position of the pits of the anterior arms of the tentorium.

## SUBGENAL SUTURES

Agreement is also expressed with Ferris that subgenal sutures, as defined by Snodgrass, do not exist. Although the inflection of the cuticle between the margins of the epistomal suture may continue laterally on each side of the head,



as shown in fig. 5, the actual suture itself does not extend beyond the margins of the frons and clypeus. The inflection is doubtless a secondary development which followed the acquisition of the anterior mandibular articulation. In certain of the Homoptera (Ulopids, a few Ledrids and Fulgoroids) the genae are separated from the maxillary plates by a suture, which has been called previously the subgenal suture (Evans, 1939). The suture in question marks the position of the attachment of the maxillary plates to the head-capsule, and is not homologous with the subgenal suture of Snodgrass.

#### ANTE-COXAL PIECES OF THE MANDIBLES

In the larva of *Archichauliodes*, small triangular sclerites occur on each side of the clypeus immediately above the mandibles. Comstock (1920), who termed these sclerites the ante-coxal pieces of the mandibles, believed them to be of clypeal origin. The evidence obtained from the head of the larval Mecopteron, illustrated in fig. 1, suggests that they are part of the antennal segment. According to Tiegs (1940) the clypeo-labrum is part of the pre-antennal segment.

#### TENTORIAL PITS

Ferris' suggestion that the pits of the anterior arms of the tentorium belong to the antennal segment, or to the intersegmental fold between the antennal and clypeal segments, is accepted. The pits of the posterior arms of the tentorium are doubtless invaginations of part of the maxillary segment and always lie on the maxillary segment, close to the margin of the labial segment.

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# **THE GEOLOGY OF THE EDEN-MOANA FAULT BLOCK**

By R. C. SPRIGG, B.Sc.

## **Summary**

This region, commencing near Marino and extending eastward towards Eden and southwards to Moana, comprises approximately 55 square miles. During recent years, Sir Douglas Mawson has critically investigated the Adelaide Series in the Flinders Ranges, and it is now of special interest to study, in detail, the corresponding succession in the southern areas of the State.

## THE GEOLOGY OF THE EDEN-MOANA FAULT BLOCK

By R. C. SPRIGG, B.Sc.

[Read 10 September 1942]

(WITH MAPS)

### INTRODUCTION AND PREVIOUS INVESTIGATIONS

This region, commencing near Marino and extending eastward towards Eden and southwards to Moana, comprises approximately 55 square miles.

During recent years, Sir Douglas Mawson has critically investigated the Adelaide Series in the Flinders Ranges, and it is now of special interest to study, in detail, the corresponding succession in the southern areas of the State.

Primarily, the mapping which constitutes the basis for the present contribution, was undertaken to obtain more accurate data concerning the thicknesses of certain beds of the Upper Adelaide Series near Adelaide, and to elucidate further the geological structure of older rocks in this area.

Lately, attention became directed to the Hallett Cove section by the reported discovery (Segnit 1940) of Sturtian Tillite on the sea coast about half a mile north of Black Cliff. Its correctness was considered doubtful, as this coastline has been traversed many times by geologists with a wide knowledge of glaciogene beds, including Professors Howchin, David, and Mawson. Howchin has not, with all his wide experience of the Sturtian and Permian Tillite in South Australia and the Pleistocene Till in North Britain, recorded Sturtian Tillite here.

The Geology Club of the University visited the locality later in 1940, and upon inspection unanimously rejected Segnit's pronouncement (see Mawson 1940).

Older rocks exposed on the block form part of Howchin's original type series. Howchin (1929), however, did not fully unravel the sequence of the upper beds, labelling them simply as "Cambrian Slates and Quartzites," the "Transition" or "Purple Series." He devoted many years to establishing the stratigraphical succession of the Adelaide Series in the neighbourhood of Adelaide, and his achievement is a very notable contribution to South Australian geology. His discovery and recognition of the Sturtian Tillite is of world-wide interest.

Other geologists, David (1896 and 1928) and Howchin (1896), have investigated problematica found at certain horizons in these beds. At present these findings are regarded cautiously. Reference will be made to them when discussing the Brighton limestones and the underlying argillaceous limestones.

Mawson (1907) drew attention to the significance of the laminations in the slates associated with the Sturtian Tillite, and discussed the petrological features of the fluvio-glacial grits and slates (Mawson 1914).

Woolnough's (1904) petrological examination of the quartzites of this area indicates the amount of detailed work necessary for the whole series. However, the scope of the present paper excludes all but fleeting references to intimate microscopic structure.

Segnit's work excepted, the only geological mapping of this area executed prior to the present contribution was of several small areas—one by Basedow (1904) of Tertiary beds overlying Tapley Hill slates around Happy Valley Reservoir, and another by R. Lockhart Jack (1926). Jack's mapping was undertaken in connection with the quarrying of Brighton limestone near Reynella. Since then additional exposures showing more structural detail have made possible more accurate mapping. Howchin mapped the outcrop of Sturtian Tillite.

Segnit's findings are not discussed at any length, as they show practically no coincidence with the writer's in detail or in broader features. Relying too much it seems upon hand specimens in recognising horizons, he has arrived by this, or other means, at remarkable and incorrect conclusions. For example, a purple slate bed, in which faulting accompanied by irregular concentrations of calcium and magnesium carbonates in the more calcareous portions, and included peculiar intraformational breccias have given the rock a somewhat heterogeneous appearance, is considered Sturtian Tillite. Mawson has shown the error of this by pointing out that sedimentary conditions accompanying the deposition of the purple slates (red beds) and Sturtian Tillite are widely different.

Elsewhere the Brighton limestone is described as a Cambrian Archaeocyathinae bed, although no fossils are produced in evidence. Comparison with accepted Archaeocyathinae horizons shows neither macroscopic nor microscopic similarity.

Under such circumstances it is considered that, beyond passing reference, it is unnecessary to encumber the present publication with detailed explanations and refutatives where views concerning the subject matter differ so widely.

#### PHYSIOGRAPHY

According to Fenner's Fault Plan (1931), the area under discussion is the southerly extension of his combined Belair-Sturt Block. Detailed work has shown that his plan is subject to modification. The Sturt Fault, which is shown as terminating in the Coromandel Valley area, actually continues to Moana. Fenner has made this latter portion part of his Mount Lofty Fault. To prevent confusion, therefore, Fenner's nomenclature is not used; the area under review receives the name of the Eden-Moana Block, and that adjacent and to the east, the Clarendon-Ochre Cove Block.

The Eden-Moana Block dips chiefly to the south. From over 650 feet above sea level in the vicinity of Sturt Gorge, the surface descends nearly to sea level at Moana. Viewed from the Adelaide Plains, the westerly extensions of the block from Eden descend gradually from 650 feet to 350 feet just south of Marino. Here the gradient increases rapidly as the sea is approached. The cliffs, save where streams discharge into the sea, average 50-100 feet in height.

Generally, topography is subdued, but where streams have cut through the older rocks, youthful characters are strongly developed. This is particularly noticeable where the River Sturt passes through the northerly scarp of the block on to the Adelaide Plains. The Morphett Vale and Hallett Creeks have their sources on the scarp face of the Clarendon-Ochre Cove Block. Their headwaters are mature, but passing into Tertiary sediments become still more subdued. Near the coast, however, the exposure of underlying Adelaide Series rocks results in youthful incised channels. Where Hallett Creek traverses the Tertiaries at the "back" of the block, Happy Valley Reservoir has been constructed.

The largest stream is the River Onkaparinga which discharges from the Clarendon Ochre Cove Block, where in its last few miles it displays decidedly youthful characters. Continuing on to the Eden-Moana Block it immediately assumes senescent features, wandering by a serpentine course in a low, wide flood plain. Comparison of earlier Lands Survey maps with the latest observations, indicates recent changes in the lower reaches. Further south Pedlar Creek traverses the block in a low, wide, well alluviated valley much choked by drift sand.

As the general surface of the block approaches base level in the south, the transverse streams progressively exhibit older characters. Their valleys are now incised on a new topography consequent upon the block faulting. The severity of these differential movements was insufficient to divert the streams along the obviously easier path along the "back" of the block.

The variation of the nature and attitude of rocks exposed along the thirteen miles of coast has resulted in diverse scenery. The arkosic grit formation just south of Marino Rocks reaches the cliffs almost horizontally before plunging on to the wave cut platform at a high angle of dip. The horizontal disposition of the beds has resulted in vertical cliffs which recede by undermining. Further to the south toward Black Cliff where steeply dipping beds have not been pierced, the cliff form is typical of undermining and consequent sliding of material down dip slopes. Practically vertical strata form the cliffs south of Hallett Cove, producing sea-stacks of resistant quartzites interbedded with more flaggy material south of Curlew Point, where wave action has eroded and collapsed a sea cave in flaggy beds weakened by crumpling.

Younger beds, dominantly unconsolidated clays of several ages, have produced at Hallett Cove a well-known feature—a more or less sheltered cove or small bay—the result of greater marine advance. Southerly shore currents have built up a short “spit” of boulders made up of the waste products of cliff retreat and Permian glacial till rewash. Along the foreshore sand dunes have formed; this feature is seen only once between Seacliff and Rocky Point.

At Christie's Beach, sand dunes, brown outwash clays with lenticular gravel beds and alluvium dominate cliff scenery. These soon give place to Oligocene clays dipping slightly south-west and overlain in turn by Miocene marls and Pleistocene sands and clays. These latter form the prominent Witton Bluff, but sand dunes appear at the mouth of the Onkaparinga. At Port Noarlunga a reef of sandy limestone with triturated fossil remains destroys the main force of incoming waves. South of the Onkaparinga mouth, Miocene marls overlain by Pleistocene clays and silts form cliffs about 60 feet high. The Miocene beds slowly pass below sea level, but reappear again south of Pedlar Creek, where they abut against the Clarendon-Ochre Cove Block.

The entrance of Pedlar Creek into the sea is largely obscured by sand dunes.

### GENERAL GEOLOGY

The “undermass” of the area consists of a conformable sequence of upper beds of the Adelaide Series. To the south these are overlain progressively by younger “overmass” beds.

The older series have been folded, and affected by faulting of two widely separated periods. The overmass of Tertiary beds has experienced only the later period of faulting, which appears to be still in progress. Slight fault-folding of the Tertiaries accompanies this later Kuscusko Period of deformation.

In the Hallett Cove area, the Adelaide Series rocks were reported by Segnit to be intensely folded and faulted, but his map with its remarkable north-south strike of beds shows practically no folding and little indication of the true structure. For example, faults are used to explain Howchin's “Great Anticline” in Hallett Creek, about one mile from the coast. Confusion between regional cleavage and bedding planes renders these field observations valueless. The absurdity of the fault mosaics can readily be seen on drawing sections through them. Hade or throw is never indicated, and as most of the faults are shown along bedding planes, they could not therefore account for one foot of displacement, although a minimum of 10,000 feet is suggested by some of the unfaulted blocks. In actuality none of these 14 faults exists. Such work is vitiated by incessant false preconceptions of complexity.

Observations made for this present paper show the Upper Adelaide Series to be thrown here into a major anticlinal fold with only minor crenulations, pitching south, and except in the Sturt Gorge where considerable overthrusting has occurred, the folding and faulting is “normal.” The eastern limb of the major

anticline has suffered "minor" folding, while the western has undergone less "minor" folding and instead is drag folded.

With the exception of an inlier of Permian till at Hallett Cove the overmass is wholly Tertiary to Recent.

### THE UPPER ADELAIDE SERIES

The lowest beds consist of pre-glacial slates and quartzites, and are not considered in this paper, as the sequence is much faulted, overthrust and folded, and must await the completion of more detailed mapping in progress north of Sturt River.

The next stratigraphical unit is the Sturtian tillite, a datum horizon of our Proterozoic formation. It should overlies the slates and quartzites conformably, but in Sturt Gorge as a result of an overthrust it appears to underlie them. It was here that Howchin first reported tillite of this age in South Australia. The tillitic nature of the unit is unmistakable. A fine-grained groundmass (now slaty) contains assorted erratics of a wide range.

The waning of the Sturtian ice age is exemplified by intercalations of fluvio-glacial grits in tillite, which finally are replaced by impure limestones and laminated slates. The overlying series of finely laminated slates grades almost imperceptibly into laminated and banded slaty limestones, and then into banded siliceous limestones. Howchin terms this the Tapley Hill Series. In spite of this gradual transition, an arbitrary division can be made into banded calcareous slates and laminated slates.

The transition into the overlying Brighton limestone is again only gradual. Thus the completion of a normal sedimentary cycle is perfectly exemplified. The series is dominantly "grey," in strong contrast to the "red beds" (chocolate series) that overlies them conformably. The Brighton limestone becomes dolomitic towards the top, the result of metasomatism during the succeeding warmer period of "red bed" deposition.

Howchin's "chocolate" or "purple slate" series often present a decidedly tuffaceous appearance, but decision as to origin must await detailed petrological examination. Curiously, the coarser sediments are dominantly grey-white in colour. Calcareous beds are uncommon but do occur, and calcium carbonate forms the matrix for some quartzites.

The chocolate series is overlain conformably by grey-white pre-Archaeocyathinae quartzites, the upper limit of which lies below sea level on this block.

### THE SEQUENCE

The following log of strata begins with the youngest stratigraphical unit. Thicknesses are given in feet.

#### PRE-ARCHAEOCYATHINAE QUARTZITES AND SLATES

- 1 *Grey-white quartzite and flaggy shales.* 1,150 feet in thickness.
  - 190 feet Flaggy shales and thin flaggy quartzites. The latter vary in thickness from a few inches to one foot.
  - 78 .. No outcrops observed.
  - 6 .. Solid quartzite.
  - 21 .. Flaggy shales and quartzites.
  - 12 .. Quartzite.
  - 75 .. Flaggy shales and quartzites.
  - 63 .. Flaggy shales and quartzites, the latter being thin and infrequent.
  - 102 .. Quartzite.
  - 27 .. Flaggy shales.
  - 40 .. "Fused" quartzite.

26 feet	Flaggy shales; a few thin quartzites.
220 "	"Fused" quartzite, poorly laminated and cross-bedded, with clay gall impressions and ripple marks; minor flaggy bands.
58 "	Flaggy shales with few thin quartzite bands.
20 "	Cross-bedded quartzites.
18 "	Flaggy quartzite.
18 "	Solid quartzite.
18 "	Flaggy quartzites and shale.
12 "	Solid poorly laminated quartzite.
12 "	Flaggy quartzites and shales.
3 "	Laminated quartzite.
6 "	Flaggy quartzite.
15 "	Solid quartzite with clay gall impressions and cross-bedding.
20 "	Thin flaggy quartzite with shaly partings poorly laminated.
95 "	Banded sandy cross-bedded purple ferruginous quartzite.

## THE CHOCOLATE SERIES

- 2 *Alternate chocolate slates and chocolate quartzites*, approximately 2,250 feet.
 

450 feet	Alternate flaggy quartzites and hard slates, chocolate- to grey-coloured. In the lower section, poorly laminated quartzites are dominant.
80 "	Mainly greenish-grey quartzite; some slaty bands. The beds are occasionally chocolate-coloured; laminations and cross-bedding are frequent.
50 "	Grey quartzites.
360 "	Purple slates and purple quartzites alternating in very regular bands about one foot in thickness. Very remarkable periodicity.
1300 "	Purple quartzite mainly, with purple slates somewhat laminated. About 300 feet above the base, the quartzites contain thin green quartzite bands.
- 3 *Massive grey-white quartzites*. 300 feet.
 

300 feet	Massive grey-white quartzites.
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- 4 *Chocolate slates* (Segnit's "Tillite"), approximately 140 feet.
 

140 feet	Chocolate slates and siltstones with minor sandy bands. Intraformational inclusions and calcareous and dolomitic chocolate slates with yellow material. These latter have an increased percentage of calcium and magnesium carbonates, and occur in the upper portions of the bed in some localities.
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- 5 *Massive Quartzites*. 270 feet.
 

100 feet	Dense pink and grey quartzite.
90 "	Sandy flaggy quartzite.
9 "	Purple phyllitic slates, well laminated.
70 "	Thin flaggy slates.
4 "	Laminated grey phyllitic slates.
6 "	Flaggy quartzite.
3 "	Banded micaceous sandstone.
- 6 *Chocolate and grey slates*. 300 feet.
 

70 feet	Laminated grey slates, phyllitic in places.
40 "	Gritty felspathic banded and cross-bedded limestone and flaggy to massive and, at times, banded quartzite.
60 "	Well laminated slates; at times phyllitic.
3 "	Quartzite.
6 "	Grey laminated phyllitic slates.
1 "	Quartzites.
125 "	Laminated grey slates, at times phyllitic.

7 *The Arkoses.* 180 feet.

- 6 feet Dense, fine-grained quartzite at times sandy and micaceous.
- 2 „ Felspathic grit with pebbles.
- 18 „ Quartzite with haematite laminations.
- 19 „ Flaggy quartzite with sandy partings.
- 18 „ Felspathic gritty quartzite.
- 9 „ Quartzite.
- 9 „ Arkosic gravelly band and quartzite.
- 9 „ Sandy quartzite.
- 18 „ Grey sandy arkosic wavy banded limestone.
- 78 „ Quartzite gritty and felspathic near the top.
- 2 „ Purple quartzite with a gravel (quartz and felspathic grains) band.

8 *Flaggy quartzites.* 200 feet.

- 200 feet Flaggy quartzite.

9 *Chocolate and grey flaggy quartzite and slates.* 500 feet.

- 135 feet Purple banded siliceous slates to purple banded quartzite.
  - 12 „ Flaggy grey quartzite.
  - 27 „ Purple siliceous slates and some purple quartzite.
  - 15 „ Flaggy grey quartzites.
  - 48 „ Siliceous purple slates with included reddish chocolate intraformational flakes.
  - 15 „ Grey flaggy quartzites.
  - 12 „ Chocolate siliceous slates.
  - 200 „ Chocolate siliceous slates with a flaggy chocolate quartzite near the top.
  - 55 „ Grey quartzites to chocolate siliceous slates.
- 10 *Chocolate siliceous slates with chocolate "flakes."* 630 feet.
- 280 feet Banded chocolate slates with reddish chocolate intraformational "flakes."
  - 350 „ Purple and chocolate banded siliceous slates with chocolate "flakes," passing into calcareous slates at the base.

## THE BRIGHTON LIMESTONES

11 *Buff dolomite and pink and blue limestones.* 100 feet.

- 50 feet (max.) Buff dolomite passing below into greyish dolomitic limestones in some localities. Oolitic structure not well developed.
- 50 „ (max.) Pinkish oolitic slightly dolomitic limestone. Dolomitization varies with the locality. Underlain by solid blue and greyish limestones (as high as 97%  $\text{CaCO}_3$ ), becoming more siliceous and banded towards the base. Oolitic structure not as plentiful as in the pink band.

## THE TAPLEY HILL SLATES

12 *Banded slaty limestones.*

- 3000 feet This formation grades more or less imperceptibly into the Brighton Limestone above and the laminated Tapley Hill slates below. In its upper portion, the bed is a siliceous limestone with fairly regular calcareous slate bands, probably of shallow water origin as cross-bedding is common. Calcium carbonate diminishes as one descends in the series, the beds becoming very calcareous slates. Towards the base laminations appear associated with the banding, which itself is diminishing. A band of chocolate "hieroglyphic" limestone 5 to 10 feet in thickness appears some 50 feet below the Brighton limestone. Blue intraformational limestone is associated with this horizon and covers a greater vertical range.



13 *Laminated slates.*

7500 feet Well cleaved finely laminated slates, poorly calcareous at the base, but  $\text{CaCO}_3$  percentage increases above. Very uniform, with only occasional thin bands of poorly laminated blue-grey limestones. No arenaceous sediments have ever been recorded in this considerable thickness of sediments.

## THE STURTIAN TILLITE AND ASSOCIATED PHASES. 1,200 +.

14 *Glacials, fluvio-glacials and limestones.* 200 feet.

4-10 feet Limestone usually in small bands in laminated slates.

30 „ Boulder tillite.

24 „ Sandstone quartzite to fluvio-glacial sandy grits. Occasionally the sandstone exhibits poor lamination.

9 „ Tillitic sandstone quartzite.

6 „ Tillite.

12 „ Tillitic grit.

86 „ Tillite.

15-30 „ Gravelly to gritty quartzite and grit.

15 *Tillite.* 1,000 + feet.

60 feet Tillite: numerous large boulders in a slaty matrix.

10+ „ Laminated slate with minor tillitic bands.

60 „ Tillite with plentiful boulders measuring up to 4 x 3 feet. Abundant erratics of granites, gneisses, quartzites and some dolomite.

20 „ Laminated and banded slates with thin tillitic bands.

15+ „ Boulder tillite. Reduced by faulting.

300 „ Tillite with perhaps a grey quartzite band about 15 feet thick near the lower limits. This may be a repetition of the following quartzite by faulting or more probably by isoclinal folding.

15 „ Grey quartzite with calcitic base.

500+ „ Boulder tillite, reduced by overthrust faulting.

## PRE-GLACIAL QUARTZITE AND SLATES SERIES

These beds are not considered in this paper.

## A DISCUSSION OF THE MAJOR SEDIMENTARY FEATURES

## THE STURTIAN TILLITE AND ASSOCIATED FLUVIO-GLACIALS

The importance of securing an accurate estimate of this datum bed has increased considerably with further studies of the tillite in the Flinders Range by Mawson (1939), but, unfortunately, in the Sturt Gorge, overfolding and overthrusting has reduced the observable thickness and, therefore, the reliability of one's estimates. Howchin's estimate of 1,000 feet is a minimum; a figure approaching 1,500 feet is more probably correct.

The base of the tillite, observed in a railway cutting near the Metropolitan Brickworks, passes abruptly into solid quartzites. This transition is not seen in Sturt Gorge, as it is overridden by overthrust pre-glacial laminated, fissile and flaggy quartzites.

The tillite typically possesses a slaty or phyllitic base, containing a varied assortment of sedimentary, metamorphic and igneous erratics, which show signs of considerable stress and are elongated in the direction of slaty cleavage.

At an uncertain distance (more than 500 feet) above the base, an even-grained, fluvio-glacial quartzite, with sharp grains of quartz and feldspar embedded in a matrix of calcite, appears (see p. 198). Above this a second quartzite band

occurs, having approximately the same dip and strike. Whether this is the same bed repeated in a close fold or by faulting, cannot be asserted. The former is more likely.

Above this approximately 300 feet of tillite occurs, overlain by a laminated fluvio-glacial bed, 20 feet in thickness. At intervals the slaty matrix contains thin bands of tillitic material. An overthrust fault to the west along cleavage renders stratigraphical relations to the next horizon uncertain. A second fluvio-glacial band (10 to 20 feet in thickness) follows an interval of 60 feet of tillite. The possibility of these two inter-glacial horizons being coincident with two occurring to the west is regarded cautiously as normal faulting alone could be responsible for this, and the strong fault observed between them is undoubtedly an overthrust.

Another 60 feet of characteristic tillite is overlain by coarse arkosic grits and gravels. In thickness it varies considerably, but discrepancy may be due to imperceptible mergence into gritty glacials and to bad exposures.

More tillite follows occasionally displaying fluvial characters; the appearance of several limestone bands and laminated slates marks the conclusion of glaciation. One limestone band analysed 66.3% calcium carbonate and 0.63% magnesium carbonate. For an analysis of the tillite and one of the grit bands see Mawson 1914.

#### THE TAPLEY HILL SLATES AND BANDED SILICEOUS LIMESTONES

In this remarkable series of more or less calcareous slates, no arenaceous intercalations have yet been discovered. Regional cleavage in the lower slates is perfect, but that of the more calcareous upper beds is poor.

The slates exhibit perfect lamination, which suggests annual deposition (Mawson, 1907). The laminae pairs are not varves, as can be observed readily in thin section; the nature of the variation of alternate layers is not one of grain size, but dominantly of chemical composition and consequently colouration. An analysis of the rock is cited by Mawson (1914).

Higher in the series, calcium carbonate percentage increases with concomitant loss of fine lamination and the institution of coarse banding. The slates were deposited in quiet and relatively deep waters, for current ripples are absent here. Cross bedding and the intraformational and edgewise conglomerates present in the upper calcareous slates and slaty limestones suggest shallower conditions; resultant upon a shallowing of the geosynclinal lake owing to continued sedimentation. The contention that these beds were deposited in a lacustrine environment is supported by the lack of marine fossils, which might be expected at this age, and the presence of laminations undisturbed by animal life.

A notable feature of corresponding beds measured by Mawson (1939) in the Flinders Range is the inclusion of a chocolate intraformational limestone, the "hieroglyphics" horizon. An identical, although much thinner band of this limestone was discovered east of Hallett Cove by the author, about 50 feet stratigraphically beneath the blue limestone of the Brighton horizon. The oolitic limestone therefore which persistently overlies the "hieroglyphics" limestone in the Flinders Ranges must be the equivalent of the Brighton limestones. The chocolate "hieroglyphic" limestone is only 5 to 10 feet in thickness, but blue intraformational limestone has a considerable vertical range.

An interesting variation in sedimentary conditions, in particular the commencement of "red bed" conditions, is noticeable in these two widely separated regions. In the Flinders Ranges, chocolate beds occur for a considerable distance below the "hieroglyphics" horizon, whereas in the Hallett Cove region chocolate colouration is not marked until immediately above the Brighton dolomitic limestones.

## THE BRIGHTON LIMESTONES

This horizon cannot be considered as a well-defined sedimentary unit; the transition from the banded limestones below is only gradual.

At Reynella, the pure limestone passes below into siliceous banded limestone and another small band of fairly high-grade limestone. Normally in quarrying, this latter band cannot be removed economically, although sometimes it is removed during 'benching' operations; it is not included in the thicknesses given for the Brighton limestone. Difficulty experienced in separating these two horizons reflects itself in quarrying, as hand separation of the good blue limestone from the fresh, more siliceous material is often difficult. Consequently, frequent analyses are necessary.

The highest grade limestone, the blue band, Howchin (1929) found to be about 15 feet in thickness at Brighton. At Reynella it exceeds 50 feet. This variation is consequent upon "similar" folding, which has caused an increase of thickness adjacent to the axial planes, and a corresponding thinning along the limbs of the fold. This transference of material is reflected in the directional elongation of oolites. In the South Australian Portland Cement Company's No. 4 quarry at Reynella, the good blue limestone is at least 50 feet thick on the roof of an anticline. In the "Beehive" quarry which was opened on the west limb of a shallow anticline, only 25 feet of blue limestone was found. At One Tree Hill near Howchin's "great" anticline, the limestone was found to be 50 feet thick on the crests of folds but only 20 feet thick on the most westerly limb. This limestone analyses from 86 to 95% calcium carbonate and from 1 to 5% magnesium carbonate.

It passes almost imperceptibly into pink limestone, which Howchin has erroneously alluded to as the main horizon quarried for cement manufacture. He records a thickness of 15 feet, evidently quoting measurements from the Brighton Quarries, where it forms a fairly well-defined horizon. In the Reynella Quarries, however, the band in some places is hardly recognisable, being a light pinkish and bluish indefinitely mottled limestone, varying in thickness. Occasionally, it appears to merge into a white limestone (analysing a maximum of 13% magnesium carbonate) which has been noticed only in the Reynella area.

Oolitic structure is common in the pink-coloured limestone, less so in the blue. Microscopically, the oolites are seen to possess concentric structure and not radial as might be expected in such pure limestone. Oolitic structure is prevalent in limestones overlying the "hieroglyphics" horizon in the Flinders Ranges. As has been noted, sedimentary conditions in the two widely separated areas are strikingly similar.

Poor intraformational breccia structures are sometimes observed in the lower portions of the Brighton limestone, but their occurrence is of less importance than in the 'hieroglyphic' band. Some of these flake patterns viewed in cross sections suggested to Professor David (1927), who carried out research on these beds, various fossil invertebrates. As the identifications were made only on outlines seen in two dimensions, the discovery cannot be given much credence.

The buff-coloured dolomitic limestone overlying the pink and blue bands is stated by Howchin to be also 15 feet in thickness, but in the Reynella vicinity it ranges to at least 50 feet, due mainly to geological structure. Depth of dolomitisation varies considerably; it occurred probably soon after deposition in consequence of subsequent warmer conditions. An average analysis gives calcium carbonate 41% and magnesium carbonate 29%.

The Brighton limestone outcrops near Hallett Cove have been designated as Cambrian Archaeocyathinae series by Segnit. No fossils were found and it was on grounds of lithological similarities alone (of which there seem none of any

importance) that his assertion is made. It will be remembered that Howchin discovered ring-like markings which he considered as possibly Archaeocyathinae in a limestone outcropping on the Willunga scarp. Madigan (1927) satisfactorily proved that this bed was the Brighton horizon and that Howchin's theory was incorrect.

The Brighton limestones series, as a whole, indicates (with minor divergences) a gradual increase of magnesium carbonate from below upwards, while calcium carbonate decreases. Partial analyses are listed below of samples of the more important bands. Colour is a fair indicator of grade, but not infallibly.

		Calcium Carbonate	Magnesium Carbonate
		%	%
Buff dolomitic limestone	-	41	29
Light grey oolitic limestone	-	62	25
Mottled pink oolitic limestone	-	48	21
Pink limestone	-	86	4.5
White magnesium limestone	-	80	13
Light grey limestone	-	90	2.7
Dark grey blue limestone (best for cement manufacture)	-	91	2.3

#### THE CHOCOLATE SERIES (Howchin's "Transition" Series)

Howchin (1929) regarded these beds as early Cambrian in age, or more correctly as beds deposited during the transition from Proterozoic to Cambrian.

Until fossils are discovered in this "red bed" series, Mawson (1939) has suggested that the base of the Cambrian be fixed tentatively at the base of the Pound quartzite which immediately underlies the Archaeocyathinae beds. An entirely satisfactory ruling may not be forthcoming for some time; facts having an important bearing on the discussion continue to appear.

In this area the chocolate series is well defined, beginning without any unconformity after the conclusion of the deposition of the Brighton limestone, but in the Flinders Ranges chocolate beds have been recorded below the "hieroglyphics" limestone horizon (Mawson, 1939).

The succession includes sediments ranging in grain size from that of gravels with rare pebbles up to one and a half inches in length, through sands and silts, to muds; calcareous intercalations are uncommon. The dominant colour is chocolate, but thick white quartzites are also prominent.

The lowest member of the series is a calcareous chocolate slate, passing above into peculiar beds to which, in the field, the cumbersome title "Chocolate siliceous slates with reddish chocolate chips" has been applied. Although these beds occur over a thickness of 1,150 feet of strata, their occurrence in the upper 500 feet is sporadic. This rock invites close petrological research, as it has many suggestive similarities with volcanic tuffs. Mawson (1939) has noted at Brachina Creek undoubted tuff beds overlying the "hieroglyphics" limestone, and, in addition, characters reminiscent of tuffs and perhaps loessial deposits in beds much higher in the succession. A similar gradation occurs in the area under review.

Immediately above the lower (?) tuffaceous series in the Hallett Cove area, there follows a well-developed series of grey-white flaggy quartzites, which exemplify drag folding to perfection. A specimen from one such drag-folded quartzite was sectioned by Dr. Woolnough (1904). Some of the beds are ripple-marked.

Overlying these are Howchin's celebrated arkoses, which far from homogeneous, vary from chocolate and grey, sandy, micaceous and arkosic quartzites, to pebbly arkosic grits. One coarser arkosic unit has a calcareous base which

weathers, leaving sandy and occasionally cross-bedded bands in strong relief. A similar but finer-grained sandy limestone, overlying this, analysed calcium carbonate 67.7%, magnesium carbonate 3.2%, and 25% insolubles.

Arkosic gravels are rare, but quartzite pebbles have been found ranging to one and a half inches in length. A petrographic description of the arkoses is given on p. 200 in this paper.

These beds are succeeded by over 300 feet of chocolate and grey slates, which are at times laminated and include some quartzites, overlain in turn by 270 feet of massive flaggy grey quartzites with a few slates.

The next stratigraphical unit has been designated by Segnit as Sturtian Tillite. The possible occurrence of this datum horizon of the Middle Adelaide Series in the Hallett Cove locality seemed highly improbable, and subsequent investigations show that this new theory is totally incorrect. The rock possesses no characters directly attributable to ice deposition.

In a note to the Royal Society in September 1940, Mawson summarises the situation thus: "Where older tillite is shown, I found mainly sandstone and shales which are gritty and arkosic in their upper limits. In one or two places small fragments of rock unhomogeneous with the main body are embedded in it, but these can well be accounted for as of intraformational origin, and, in other cases as scattered spots in the rocks which have suffered subsequent chemical change, the original red colour having been bleached to yellow. I could find nothing in the nature of true tillite. Indeed, the prevailing colour of the rock is good evidence that this is not a glacial bed."

The main outcrop of this bed occurs in the sea cliffs south of Marino. It is of supreme significance to realise that the wave-cut platform here is the locus of a compound Palaeozoic fault having to the east. The fault zone is extensive, although downthrow does not exceed 20 feet, and contains quartz stringers and remarkable crush breccias in its northerly extensions. Where it cuts the bed under discussion the fault zone becomes even more broken, being more in the nature of a general disruption of the rock, which outside this zone is a normal well-laminated slate. Thin dolomitic bands have been shattered, and owing to the broken nature of the rock irregular splashes and vughs of calcite and dolomite have formed. It is these, together with intraformational structures, which have given the rock a faintly tillitic appearance.

A pseudotillitic specimen was selected for examination; it has a dolomitic slaty base in which homogeneous golden fragments of a material more dolomitic than the base are embedded. A partial analysis of the yellow dolomitic fragments is  $\text{CaCO}_3$  45%, and  $\text{MgCO}_3$  36.7%. The base analysed 29.0%  $\text{CaCO}_3$ , and 17.9%  $\text{MgCO}_3$ . Such a composition could not be expected in a normal tillite unless ice was eroding almost wholly calcareous and dolomitic beds over a tremendous area. In a typical analysis of the Sturtian Tillite quoted by Mawson (1914) the percentages of  $\text{CaCO}_3$  and  $\text{MgCO}_3$  are 3.14% and 2.69% respectively. Thus it is readily evident that there is no resemblance in composition. In addition, the Sturtian Tillite is always dominantly grey in colour, never purple as is this unit.

Diligent search, both in the field and in micro section, has failed to reveal any composite grains. This fact is in itself convincing.

Any claim that geographical separation could account for the obvious discrepancies between the bed and the recognised Sturtian Tillite is illogical, as the latter bed is relatively constant in character over areas of thousands of square miles separated by considerable distances. Further, there is no correlative evidence for tillite at this horizon elsewhere in this State, nor is there the slightest evidence for the displacement by faulting of a block of Sturtian Tillite to this locality.

Thus colour, composition,, restriction of fragment type, absence of composite grains, obvious water sorting in almost the entire bed except at the fault described, general appearance and field evidence, prove beyond all reasonable doubt that the bed is not tillite.

The overlying bed of massive grey-white quartzites attains 300 feet in thickness; it includes several minor purple slate bands. It is succeeded by purple quartzites and purple slates, often well laminated. North and south of Hallett Cove the lower beds (dominantly quartzitic) include green bands of chloritic quartzite. These, though thin (usually one-quarter of an inch in thickness), are remarkably persistent, being constant in appearance over the full extent of observable outcrops from Black Cliff to Morphetts Vale Creek. At Black Cliff they formed slippage planes during drag folding, and consequently considerable green blatter has been formed (see p. 203).

For a thickness of 360 feet the purple slates and quartzites display extraordinarily regular periodicity, as yet to be investigated.

Grey and greenish-grey quartzites, overlain by chocolate and grey alternate slates and quartzites, complete the purple series.

#### PRE-ARCHAEOCYATHINAE GREY QUARTZITES

This sequence of grey-white "fused" and flaggy quartzites and flaggy slates forms a prominent feature along the coast south of Curlew Point. The beds which dip almost vertically, correspond closely and were deposited contemporaneously with outcrops at Ochre Cove and the quartzites and slates mapped by Madigan (1927) on the Willunga Scarp. This is important, as it indicates the proximity of Archaeocyathinae limestones just seaward of Rocky Point and Ochre Cove.

Minimum thickness of the unit is at least 1,150 feet, and according to the expected ratio of increase from the succession at Willunga Scarp (see fig. 1) should approximate 2,000 feet. This seems to indicate that this horizon is the equivalent of Mawson's Pound Quartzite (maximum 3,000 feet at Wilpena Pound). Clay gall impressions which are so common in both these formations have no stratigraphical significance. They occur in many Adelaide Series quartzites.

#### EVIDENCE AS TO THE RELIABILITY OF THE ESTIMATES OF BED THICKNESSES

That faulting has had little or no effect in accentuating or reducing the observable thicknesses of strata in this area other than in the case of the Sturtian Tillite, is conclusively proved by a comparison of Madigan's (1927) Willunga Scarp table of strata with that of this locality.

It has long been realised that Willunga and Myponga are progressively nearer the southerly shore-line of the old geosynclinal basin in which the Adelaide and Cambrian Series were deposited. The continued wedging of the tillite southwards is important evidence in this respect.

Howchin estimated the thickness of Sturtian Tillite at approximately 1,000 feet near Eden. The author agrees with this as a minimum estimate (the true thickness probably approaches 1,500 feet), but the occurrence of considerable overthrust faulting here demands caution. Howchin, when mapping the tillite and associated beds near Noarlunga (on the Clarendon-Ochre Cove Block) did not estimate the thickness of tillite. Madigan (1927) observed a thickness of 150 feet of tillite near Willunga, but this has dwindled to 78 feet near Myponga. Hence graphing the distance south of Adelaide against tillite thickness would show a steady thinning of the bed to the south. In support of this, the extensions of the Sturtian Tillite in the middle and far north of this State as measured by Mawson (1939) and others show expected enormous increase in thickness.

## CORRELATION TABLE

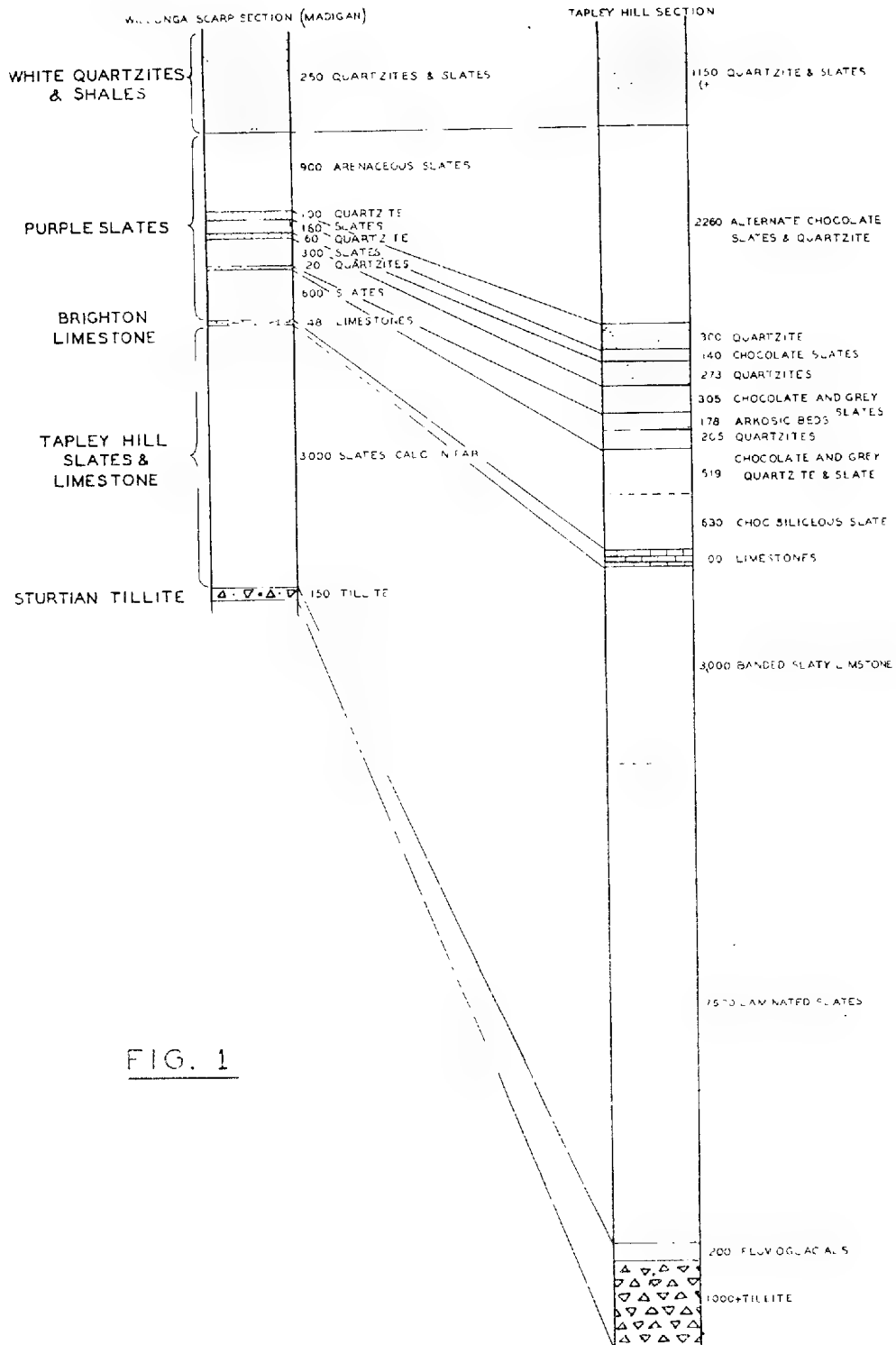


FIG. 1

Similar thinning of post tillite beds is evident when the author's measurements are compared with those of Madigan's Willunga Scarp section (see fig. 1). A very approximate estimate of the thickness of the Tapley Hill slate series near Noarlunga (deduced from Howchin's map, sections and descriptions) is 5,000 feet. Comparison of this figure with Madigan's 3,000 feet at Willunga and the author's 10,500 feet at Tapley Hill show expected variation with distance north and south.

#### PETROLOGICAL NOTES

The following selection of described rocks from the Adelaide Series is far from comprehensive, but serves merely to illustrate certain important points or features.

##### FLUVIO-GLACIAL QUARTZITE (Sturtian Horizon)

The specimen was collected in the Sturt Gorge to the west of the main overthrust. Macroscopically it is a light-grey, fine, even-grained quartzite with a rather flat fracture. It will not scratch easily, and therefore appears to consist largely of quartz. No laminations are discernible in the hand specimen.

In thin section, fine, somewhat angular quartz and felspar grains are seen set in a ground mass of granular calcite. The angularity of the grains and the presence of felspar, in addition to stratigraphical relations, indicate fluvio-glacial origin. Heavy mineral concentrations follow rather fine current laminations. These latter prove that the quartzite is not a sandstone dyke.

Quartz is by far the most plentiful mineral in the section and shows no sign of secondary growth. The grains are subangular or angular, and exhibit shadow extinction. Grain size averages 0.2 mm., but individual grains range to 0.3 mm. Subangular and slightly rounded grains of microcline, some exceeding 0.2 mm. in length, are present in small quantities, with little alteration. Plagioclase of varied composition is not common and alteration is slight.

Although calcite forms the matrix it is not abundant. Small rounded and subangular grains of zircon occur, concentrated in heavy mineral laminations with biotite flakes, rounded or subangular tourmaline grains, and irregular grains of iron ores. A few grains of apatite are present.

Irregular stains and a few grains of iron minerals occur in the general mass of the rock. Light green flakes of chlorite are uncommon.

##### SILICEOUS GREY LIMESTONE (Tapley Hill Series)

A specimen was collected from the S.A. Portland Cement Company's No. 4 Quarry at Reynella immediately underlying the Brighton Limestone horizon. This limestone is fine-grained, even textured, and microcrystalline.

Practically no structure is visible in the fresh specimen but a weathered surface exhibits banding. An etched surface reveals quartz concentrated in bands. There is considerable interlocking of grains.

In thin section, granular calcite with much included impurity forms a considerable proportion of the rock. Quartz grains, many with shadowy extinction, are abundant and possess irregular angular form. Some silica is secondary. A few chlorite and sericitic flakes are present. Minute grains of plagioclase and flakes of biotite are probably authigenic.

Partial analyses of this limestone show that the percentage of calcium carbonate varies considerably (40-80%) and magnesium carbonate remains at 3-5%.

##### "VERMICULATE" LIMESTONE (Blue "hieroglyphics" Limestone)

This occurs in the siliceous limestones of the Tapley Hill Series. It is a light greyish microcrystalline limestone in which numerous lithified flakes of grey calcareous mud are set. The flakes are typically intraformational and a gradation



is noticed from intraformational breccia to edgewise conglomerate. Most of the flakes are flat, but there is a tendency to turn at the edges; length varies from several to 20 mm. In thin section or on polished faces there is a superficial resemblance to annelids (see David 1928), but this is quite lost when the third dimension is considered.

Etched and thin sections reveal the base to be less homogeneous than the flakes which are largely of calcitic mud with little quartz. The groundmass consists largely of irregular silica grains usually interlocking in firm aggregates; it is really a very fine calcareous silt.

Odd flakes of sericite and chlorite are present, particularly along lines of stress. Limonitic stains are uncommon.

#### OOLITIC GREY-BLUE LIMESTONE (Brighton Horizon)

This is grey-blue, even-grained microcrystalline with plentiful flash faces of calcite. Small calcite veins are not common. There is no visible banding or oolitic structure. Magnification shows much of the calcium carbonate of the ooliths to be replaced by concentric shells of secondary silica. Sand grains as nuclei have suffered considerable secondary growth; other nuclei are completely of secondary silica. The granular nature of the secondary silica may be due in part to replacement of finely crystalline calcite layers.

Outgrowths of silica from nuclear masses appear identical with the bars of silica from the "medulla" of supposed radiolaria described by David and Howchin (1896) from this horizon. There is no reason to believe that any of these structures are radiolaria, as all gradations from typical ooliths can be seen. A few of these structures show two concentric "shells," but the structure of the shells is in no way suggestive of such fossils. Less frequently there are three shells, so any particular arrangement is merely fortuitous.

A study of thin sections of the rock confirms the above views. The ooliths are not well layered and the distinction of adjacent layers is dominantly concerned with fineness of granulation of the calcite; impurities probably heighten the difference and may control it.

Partial analysis of an average sample gave 91% calcium carbonate and 2.3% magnesium carbonate.

#### PINK LIMESTONE (Brighton Horizon)

A pink-coloured, even-textured microcrystalline limestone with a few small brown intraformational flakes of more argillaceous (and possibly more dolomitic) material. A few calcitic cleavage faces and minute chloritic flakes can be distinguished. No oolitic structure is visible macroscopically.

Etched surfaces and microscopic sections show the rock to be very similar to the underlying blue limestone. This is further evidence that these limestones are not two well defined horizons, but that the upper pink bed is a slightly more dolomitised and ferruginised equivalent of the blue band. Irregularity of the thickness of the pink limestone and thus of the depth of dolomitisation supports this view.

The specimen selected has intraformational platy masses of calcareous silt. Ooliths exhibit similar characters to those occurring in the blue limestones; some have nuclei of coarsely crystalline calcite.

Occasionally authigenic quartz shows a tendency to be euhedral. One such crystal measured 0.8 mm. by 0.25 mm.

Partial analysis of the limestone gave calcium carbonate 85.7% and magnesium carbonate 4.7%.

### BUFF DOLOMITIC LIMESTONE (Brighton Horizon)

A buff-coloured rock; the more finely-textured portions break with an almost subconchoidal fracture, while that of most of the rock is less even. Minerals present in the hand specimen are for the most part indeterminable, but calcite cleavage faces can be discerned. Manganese stains and dendrites are common; siderite is less evident.

Etched surfaces, when magnified, reveal much fine even-grained secondary silica embedded in granular calcite and (?) dolomite. Limonitic and manganiferous matter stains the rock; veins of silica etch in strong relief.

Calcitic oololiths are plentiful in some sectors, and many of these have outer layers replaced completely by granular secondary silica. Some have several concentric shells or a nuclear mass of secondary silica. A possible selective action of dissolved silica on the varying granularity of the calcite (or original aragonite) layers is suggested. Dimensions of the oololiths range from 1-3 mm. There is no suggestion of radiolarian structure.

In thin section the base is seen to be of rather impure granular calcite in which oololiths of granular calcite, replaced in part by secondary silica, are abundant.

A representative specimen of this dolomitic limestone analysed calcium carbonate 41%, and magnesium carbonate 29%.

### ARKOSE

A specimen was collected from Waterfall Creek, one mile north-east of Hallett Cove. It is a greyish-pink medium-grained sedimentary rock in which rounded and subangular waterworn grains of quartz and felspar are dominant.

Thin sections reveal larger grains of quartz and felspar embedded in a thin matrix of silty and sandy quartz. Larger rounded grains of quartz, some with secondary growth, exhibit shadowy extinction. Secondary additions to the silty quartz of the matrix has led to some fusion of grains.

Microcline with characteristic cloudy alteration and some with minute inclusions is not uncommon. Particles of orthoclase are few. Plagioclase is plentiful, some apparently reverting to a confused antiperthite. Sericitic alteration products are frequent.

Odd rounded grains of finely crystallised chalcedony are present. Sericite and palely pleochroic chlorite occur in the ground mass. A black opaque grain is possibly carbonaceous and siliceous.

Zircon particles are quite common, but apatite and tourmaline are rare. Iron ores are present in small amount.

Petrographic and field evidence does not favour the association of cold climate with the formation of this arkose. An absence of composite particles would seem to preclude glacial action, although it does not prove the absence of fluvio-glaciation.

The horizon is included within a vast "red-bed" series, and as arkoses are prevalent in dry regions, arid or semi-arid conditions probably existed when this arkose was being deposited. The sediment is largely of the nature of a lacustrine lag gravel or coarse sand associated with aridity or semi-aridity.

### SANDY LIMESTONE (Arkose horizon, east of Hallett Cove Railway Station)

A light grey coloured rock, finely grained and coarsely laminated, the laminations measuring one to five millimetres in thickness. Quartz sand is concentrated into laminae. Finely granular calcite forms the mass of the rock.

Secondary accretion of silica has led to much interlocking of grains into bands, which etch in strong relief. Oololiths are present in the more calcitic laminae.

In thin section granular calcite is seen to form the mass of the rock. Quartz grains arranged in bands are largely sub-angular, and the effect is heightened by secondary growth. Grain size rarely exceeds 2 mm.; a few grains of iron ore are present.

Ooliths ranging to 0.5 mm. in diameter are present in the less sandy laminations but are never plentiful. Very little concentric structure is evident; nuclei of quartz grains are uncommon.

A partial analysis gave calcium carbonate 67.7%, magnesium carbonate 3.2%, and insolubles 25.0%.

#### FISSILE SILTSTONE

(Specimen taken one-quarter of a mile south of Hallett Cove, along coast)

This siltstone is dominantly chocolate-coloured and contains a thin band 3 mm. in maximum thickness of more reddish chocolate slate in which manganese dendrites are distributed plentifully. Secondary micaceous minerals are abundant.

Fracture is rather irregular. Parallel and cross laminations can be seen with difficulty; some exhibit concentration of heavy minerals.

Microscopically the mass of the rock is fine argillaceous material in which orientated sericite (parallel to slaty cleavage) and even-grained fine angular quartz rarely exceeding 0.02 mm. in length is embedded. Earthy and granular iron ores are plentiful in the base.

Lamination is dominantly concerned with the amount of included iron ores. Some laminae are almost wholly of lightly packed angular magnetite grains.

A slaty band differs from the bulk of the rock in having less silty but more sericitic and argillaceous matter. The rock was selected in the hope that evidence of volcanic activity might be discovered.

No composite grains are present, but the rock may represent a rewashed volcanic ash or an allied sediment.

#### BANDED PURPLE SANDSTONE QUARTZITE

(from the base of the Pre-Archaeocyathinae Quartzites, Curlew Point)

Purple irregularly banded quartzitic sandstone, whose thinner bands are lighter coloured or greyish. Peculiar white clots are a feature of this rock. Quartz grains of the dimension of coarse to fine sands form most of the quartzite; various iron ores are intergranular or concentrated into bands.

Grain size varies from 0.1 to 0.8 mm., but averages 0.4 mm. The clots referred to above are aggregations of chalcedony with irregular boundaries and include a little quartz and iron ore fragments.

Quartz displays very marked shadowy extinction. Secondary growth of the grains has resulted in some fusion of adjacent grains and a crowding of intergranular iron ores.

Small pockets in which magnetite is altering on the periphery to haematite, are themselves lined by orientated chalcedony.

#### THE AGE OF THE UPPER ADELAIDE SERIES

In Australia the transition between Proterozoic and Cambrian is indefinite; hence Howchin's "Transition" series (1929). However, some division should be made, even though arbitrarily. In the Upper Adelaide Series, no undoubted structural unconformity at which Cambrian could be considered as commencing is known. Segnit (1939) claims that a disconformity or unconformity occurs between the Pound quartzite and the Archaeocyathinae limestones, but the researches of Mawson (1939, etc.) and Madigan (1927) fail to substantiate this.

As no fossils (excluding problematica) occur below the Archaeocyathinae limestone, then sediments alone must be relied upon to furnish clues for the solving of the problem. After a study of the sedimentary succession it is evident that the

remarkable quiescent period which culminated with the deposition of Brighton limestone is succeeded by a series of sediments which are definitely "Flysch" in character. These grade from calcareous chocolate slates at the base through normal chocolate slates to quartzites, attaining the coarsest phase as arkoses and arkosic gravels. The introduction of this suite of sediments is coincident with the institution of "red bed" conditions following a long period during which a "grey" series, including tillite, was deposited. This indicates a considerable environmental change which may mark the commencement of the Palaeozoic. Contemporaneous volcanic activity known definitely to have been associated with the chocolate series (Mawson 1939) in the Flinders Ranges and probably this region, supports the contention. The rather rapid evolution of environmental conditions from cool or frigid to warm and arid presents striking analogy with conditions existent during the late phases of the Palaeozoic. Glaciation of the Permian Period undoubtedly quickened the evolution of plants and animals. Similarly the late Proterozoic ice age is probably responsible for the sudden appearance of highly organised Cambrian fauna.

As mentioned, Mawson (1939) has suggested that the Cambrian include the pre-Archaeocyathinae or Pound Quartzite. The discovery of Lower Cambrian fossils in the equivalent chocolate series in North America (Chamberlin, 1935) and the identification of the Archaeocyathinae with the upper portion of the Lower Cambrian and the Middle Cambrian (David, 1927), suggests that the upper limit of the Proterozoic will eventually be moved back.

## TECTONICS

### 1 *Folding*

Generally, folding is not intense in this area. The situation has been over-estimated by Segnit who speaks of the beds as "highly disturbed" and "severely contorted and crushed." The importance of a few minor folds and dragfolds has been exaggerated.

The author's investigations show the older beds to be disposed in a major anticlinal fold with a southward pitch ranging from 3-20° (save where faulted). The limbs of this structure have undergone minor and drag folding. Of this relatively simple structure Segnit seems to have been unaware, attempting to explain it with a complex series of faults.

On the west limb of the anticlinal structure a minor fold, scarcely distinguishable at Marino, becomes more marked when traced southward, reaching its greatest development at Black Cliff, where it consists of two small anticlines pitching south at 17°.

The centre portions of the major structure are thrown into minor folds, which, appearing as undulations, pitching south at 3-5°, die out both to the north and south of Hallett Creek. This phenomenon is explained by the transference of material in the Brighton limestones from the limbs of folds into the crests and troughs as noted previously ("similar" folding).

This gives in Hallett Creek an appearance of intensified folding. But slate outcrops appear to the north of this creek and southwards quartzites also occur. These, by their nature, display only slight "similar" folding, and in the case of the quartzites the "parallel" type alone. The minor folds exposed in Reynella quarries pitch south at 19°.

The continuation of the major structure in Sturt Gorge is relatively insignificant, as the fracture of the lower beds and consequent overthrusting has relieved compression. Beds to the east of the overthrust, however, are faulted and folded to a considerable extent. The overthrusting is accompanied by drag folding, which is quite local and represents the original deformation of a fluvio-glacial sediment, just prior to faulting. Sigmoidal fracture cleavage accompanies folding and acts

as a locus for the deposition of quartz. Slickensiding on bedding planes illustrates the relative movement of adjacent beds in synclines exposed in Reynella quarries. Thin green quartzite bands in the purple slates outcropping at Black Cliff have formed copious "blatter," separate layers of which can be scaled off. These have "fossilised" various directions of adjustments during folding. Movement is dominantly transverse to the axial planes of the folds, but some "striations" are inclined considerably to this mean.

Pocket gouging is exposed over a large surface (bedding plane) on the eastern wall of the old Brighton (now Linwood) quarry. The rock is an argillaceous limestone and presents a pseudo ripple-marked appearance. Each pocket or depression is slickensided and possesses a film of clay gouge. Here also the movement of relatively "competent" limestones which sandwich incompetent calcareous slates has produced interesting fracture cleavage.

## 2 *Faulting*

Contrary to the claim of complexity put forward by Segnit (1940) the author considers, after careful examination, that faulting falls into two groups. The first, of the overthrust type, is concerned with the development of compressional stress accompanying orogeny in the Palaeozoic era. The other faults are normal or reverse, the latter probably being pivotal and therefore passing into normal faults along their outcrop. All faults observed exhibit the phenomena characteristic of their type.

Overthrust movements have been observed only in Sturt Gorge. The first fault of this type is encountered at the junction of the pre-glacial slate and quartzite with the Sturtian Tillite. It is undoubtedly the major overthrust plane of the area and dips to the east at 20-30°. The quartzites and slate series have over-ridden tillite to an unknown extent. Brecciation along the contact is considerable and quartzite fragments are embedded in a silicified and quartz-veined slaty tillite matrix. To the west the next important overthrust is along good tillite cleavage and so averages about 45° hade to the east. Drag effect is in evidence. Throw is probably in excess of 40 feet, as the two laminated slates used in this determination may not correspond. The difficulties in this direction are considerable, as there are at least two, and possibly four or more, similar fluvio-glacial intercalations, each ranging up to 20 feet in thickness.

A third, more westerly overthrust shows practically no brecciation, but drag is particularly well demonstrated. Laminated slates abut abruptly against tillite. The slates exemplify sigmoidal fractures which subsequently have been filled with quartz. Several smaller overthrusts are marked by similar "sigmoidal" and "gash" quartz veins, and these can be seen at intervals between the three major faults.

The most westerly reverse fault observed in this locality dips at 85° to the east. Throw is about 40 feet to the west. The fault zone is marked by a strong quartz reef, and as hade is small it is possible that the fault is pivotal and would re-appear as a normal fault further south.

Most normal faults which could be studied adequately occur to the west of Reynella. They all dip to the east nearly vertically. Throw varies from a few inches to at least 60 feet. The fracture zones usually have been the locus of the deposition of quartz which occurs as thin stringers, or less frequently, as solid quartz reefs attaining about 4 feet in thickness.

One such fault can be traced for two miles in a north-easterly direction, crossing Hallett Creek just westwards from Howchin's "Great Anticline." It is marked by a strong quartz reef which occasionally bifurcates and re-unites. Its northerly extensions become almost unrecognisable, being indicated merely by a zone of quartz stringers.

The roof of the major anticline is broken by at least five normal faults, all hading to the east at very low angles. Drag phenomena and quartz venation are in evidence in each case.

The finest development of normal faulting is to be seen in one of the Reynella quarries. The fault is compound and well developed for an observed distance of 200 yards; the zone was traced for a quarter of a mile. Its south-westerly extensions are defined by quartz veins, fracturing, discontinuance of bed outcrops and travertinous surface zones.

A well-defined normal fault is exposed on the platform of marine erosion to the south of Marino Rocks. The fault zone is strongly developed for at least half a mile and is marked by coarse crush breccias except where the more northerly outcrops of purple slate is cut. The bed has been shattered considerably, which effect, combined with irregular deposition of quartz and calcite, gives the rock a pseudo tillite appearance (see above). This fault hades to the east at 50-30°, and displacement where observed exceeds 10 feet.

Whether these old normal faults are compensatory to overthrust faulting occurring to the east (*i.e.*, isostatic) has not been decided.

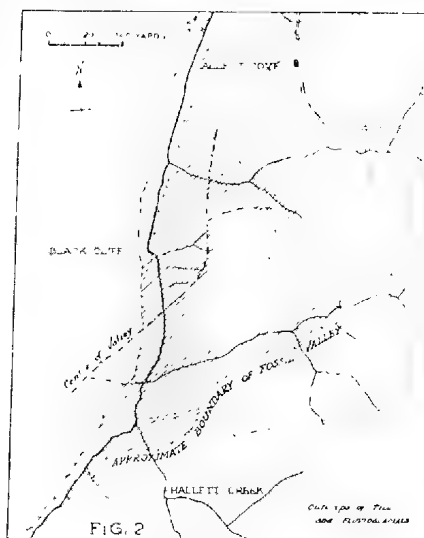
#### LATE PALAEOZOIC GLACIATION

A small remnant of this widespread glaciation occurs as an outlier in the neighbourhood of Hallett Cove. The sediments are mainly fluvio-glacial, but true till is plentiful.

The glaciogenic beds consist of red, yellow, white, and brown clays, with frequent sandy intercalations and a few erratics. Mudstones are a feature, and true varves have been found. These pass below into typical boulder till with numerous striated, soled and faceted erratics. The fluvio-glacial assemblage is typically that deposited in a glacial lake during the retreat of an ice sheet. Till is exposed in the cove at low tide; the boulder clay base is hardened somewhat and contains fairly numerous erratics. South of this exposure, the sub-aerial and marine erosion of Permian till has formed a coarse boulder shingle with one Victor Harbour granite erratic weighing approximately 5 tons. Adelaide Series rocks and granites, gneisses, porphyries, pegmatites, and schists occur commonly as erratics.

The abundance in the till, of Victor Harbour granites and various porphyries similar to South-East occurrences, suggest movement of the ice sheet from that direction. This is supported by a study of striation directions on bed rock. Nevertheless, discretion must be exercised, as the old "fossil" valley (see fig. 2) may have influenced the direction of ice movement locally. The ice would tend to flow in a more northerly direction along the valley and overflow towards what is now St. Vincent Gulf. However, the immensity of the glacial sheet probably prevented significant deviation of striation direction.

That the old relict valley lies transverse to the present drainage system has been an important factor in its preservation.



Along the coast north of Black Cliff its western wall can be observed sloping landwards along practically the whole of its present length. Apparently river action previous to Permian glaciation had incised a valley along the syncline of a minor fold in the Adelaide Series rock, for the existence of a depression at least 100 feet in depth in hard, unbroken quartzites cannot be explained by mere glacial scooping. Glaciers may have deepened this valley, but upon retreat of the ice it became choked with glacial debris and finally the site of a small lake. Southerly extensions of this valley trend south-westerly, and disappear beneath St. Vincent Gulf.

Black Cliff and sites to the north are famous for striated and occasionally fluted bed-rock. Segnit has pointed out the misapplication of the term striated pavement.

The tillite passes nonconformably or disconformably into fossiliferous Pliocene calcareous sandstone containing small erratics concentrated by wave action. A section of the fluvio-glacial and glacial sediments and the underlying and overlying beds exposed on the south side of Waterfall Creek (north of Hallett Cove) is detailed by Segnit. Two nonconformities and a disconformity may be seen. Reddish and yellow clays and the Fontainebleau sandstone (Mawson, 1907) dip at  $20^{\circ}$  to the east-south-east and wedge out to the west. This provides additional proof that a valley existed to the east, a point which previous authors, including Howchin and Segnit, have overlooked. Such overlap is typical in small lacustrine basins.

#### THE AGE OF THE YOUNGER TILL

Originally, by analogy with tillites occurring in the eastern States of Australia (particularly at Bacchus Marsh), it was suggested that the younger tills of Fleurieu Peninsula were late Palaeozoic in age. The former contain the characteristic Gondwana land flora. No other Australian tills were known with which the South Australian occurrences could be correlated satisfactorily. Evidence from stratigraphical researches merely indicates an age between Cambrian and Miocene.

With evidence based principally on a supposed analogy with small marine erratic horizons occurring in the lower Cretaceous series of the Great Artesian Basin (Brown, 1894, etc., and Ward, 1925), upon a consideration of the lithology of the beds, and on his interpretation of faulting, Segnit suggested that the Hallett Cove and related tills are Lower Cretaceous.

Many geologists have reported erratics scattered on the surface of the more south-westerly outcrops of marine Cretaceous in the Great Artesian Basin. This evidence is significant, but it must be realised that the erratics were dropped from marine icebergs. Today bergs are known to wander into latitudes lower than  $S. 40^{\circ}$ , and these, on melting, would scatter included debris into muds characteristic of moderately warm climates and so create anomalous associations of sediments. Although latitude  $40^{\circ}$  S. passes through Tasmania, no one would suggest that it is undergoing a severe glaciation in which great moraines up to 2,000 feet thick are being deposited over thousands of square miles. Thus, by analogy, the occurrence of poor erratic horizons in Cretaceous Marine sediments in the central Australian region does not explain the deposition of beds 1,970 feet thick (Hindmarsh Valley) which evidence a period of glacial severity comparable only to the Bacchus Marsh occurrence.

Secondly, Segnit is concerned by lithological dissimilarities between the undoubted Permian tillite of Bacchus Marsh, with the Hallett Cove till. This is inconsistent firstly because there is no marked similarity between the Cretaceous and Hallett Cove deposits, and secondly because greater dissimilarities do not prevent his correlating the reddish slate already discussed with Sturtian Tillite. It should be noted in this connection that a geographical separation of 500 miles between the Victorian and Hallett Cove deposits allows for some lithological differences.

Nor can the degree of lithification be accepted as decisive. Segnit remarks that in South Australia "the formations in all the localities examined by the writer are unconsolidated sediments except due to subsequent infiltration of oxide of iron, but it is noted that varves and tillite of equivalent age occur at Black-fellow Creek, which are quite hard and even porcellaneous. Also, as ancient (Cambrian) sands are known which are still quite unconsolidated and, as the converse also applies, lithification is not a conclusive indication of age.

Segnit's third argument is based upon a fault of Tertiary age allegedly cutting the till. No evidence of this may be found.

The discovery of plant remains in associated till on Kangaroo Island by Mr. Kleeman in 1940 may ultimately have an important bearing on the problem. These fossils have been submitted to Professor B. Sahni, of Lucknow University, India. Pollen grains, if found, may provide a solution. Until then the original decision, namely late Palaeozoic, must stand as supported by the greater evidence.

#### OLIGOCENE LACUSTRINE SEDIMENTS

A considerable stratigraphical hiatus exists in the Adelaide region subsequent to the deposition of Permian glaciogene beds. Following a long period of sub-aerial peneplanation a series of lacustrine sands and clays were laid down. These are all grey-white in colour, except where infiltration of iron oxides has produced mottled ferruginization near the surface.

The series is typically lignitic in South Australia, and is overlain disconformably by fossiliferous marine Miocene and possibly marine Upper Oligocene in some localities. By analogy with similar lignitic beds occurring in Victoria their age is considered Oligocene.

The clays and sands are always well sorted and bedded and the sand grains rounded or subangular. Silicified wood was recovered from a well sunk on the Reynella Distilleries property. The development of lignite on the Eden-Moana Block is poor, one small seam occurring at Port Noarlunga. Bores sunk at the direction of the Mines Department (see Mining Reviews 37, 39) reveal a maximum of 19 feet of brown coal, but this thickness is abnormal; the others have 4 feet or less. The limited extent both horizontally and vertically, in addition to difficult water problems, depth of overburden, high ash and sulphur content, with remoteness from an industrial centre, render the deposit valueless.

The Oligocene sediments can be examined to the north of Witton Bluff, in railway cuttings near Reynella and in the overflow channel of the Happy Valley Reservoir. In the latter locality these sub-horizontal sediments overlap a peneplaned surface of Tapley Hill slates which rises to the north-west. Overlying Pleistocene mottled sandstone bears disconformable to nonconformable relations with these beds.

Oligocene clays (exposed by the erosion of overlying fossiliferous beds) outcrop extensively over the northern extensions of the block. This occurrence is described by Howchin (1933) in discussing the Dead Rivers of South Australia. The whole scheme of his researches in this field can be questioned and will be dealt with in a subsequent publication. Considerable accumulations of sands and clays at Hope Valley, Happy Valley and Baker's Gully are interpreted by him as remnants of a large Pleistocene river. Actually these are outliers of Oligocene fresh water beds (in addition to Post Pliocene mottled sandstone which are re-washed Oligocene dominantly), which have been exposed by erosion and removal of the Miocene and latter formations on blocks tilted down in the south. Lignite beds at Payneham are regarded by Howchin as part of a Pleistocene lake; it is difficult to understand how he relates these to similar lignitic clays and sands occurring to the south on the Adelaide block at increasing depth. Both the Eden-Moana and the Clarendon-Ochre Cove fault blocks have foundered in the south or conversely,



uplifted in the north, and because of erosion of the overlying Miocene from the higher positions of the block Oligocene clays and sands with included silicified wood have been exposed in the north.

The bore log which follows records the maximum thickness of lignite encountered on this block. Except for local abnormal thickening of the lignite, the log is typical of bores sunk near Noarlunga.

Description of Strata	Thickness in Feet
Dark sandy clay - - -	14 feet
Pyritic sandstone - - -	1½ "
Dark clay with fine sandy partings - -	37½ "
Lignite - - -	1½ "
Carbonaceous shale - - -	¼ "
Lignite - - -	19 "
Carbonaceous shale - - -	½ "
Light sandy clay - - -	7 "
Bedrock	
Total	81½ feet

#### THE MIOCENE MARINE FORMATION

Miocene sediments overlying the Oligocene fresh water series disconformably form much of the overmass of the block. They are dominantly grey glauconitic marls. Glauconitic bryozoal limestones, with *Cassidulus longianus*, similar to those at Blanche Point occur infrequently, e.g., in an old well half-a-mile west of Hackham, one of the lowest beds consisting almost entirely of fossiliferous incoherent glauconitic sand with included polished, rounded fragments of limonite.

Marls outcrop widely south of Hackham and Port Noarlunga. North, except for one exposure about three-quarters of a mile east-south-east of Reynella, Miocene sediments are found only in bores and in the contour channel about Happy Valley Reservoir (Basedow, 1904).

The fossil content of these beds is not considered here; *Turritella aldingae*, often with internal casts of silica is dominant, being present particularly in the lower marls to the exclusion of practically all other macroscopic fossils.

Generally the beds are subhorizontal or dip south or south-westerly at angles varying up to 5°. The only deviations are seen along the fault line at the back of the block. North of Noarlunga and south of Moana the marls are dragged up against the Clarendon-Ochre Cove Block at angles often about 25° to the west or north-west. On the south bank of the River Onkaparinga the beds are but slightly disturbed, dipping to the westwards at 2 to 4°.

The following is a typical section of the Miocene marine series met with during boring operations at Noarlunga (Mining Review, 39).

Description of Strata	Thickness in Feet
Yellow clay with quartz pebbles and <i>Turritella</i>	11½ feet
White shell limestone with <i>Turritella</i> -	37 "
Dark sandy clay - - -	7 "
Ferruginous clay sandstone with marine fossils	7 "
Dark sandy clay with fossils -	12 "
Iron-stained sandstone with marine fossils -	12 "
Medium-grained dark sandstone -	12 "
Dark sandy clay with marine fossils -	5 "
Soft grey clay limestone with marine fossils -	85 "
Grey fossil limestone - - -	56 "
Grey to green shell limestone (glauconitic bed) - - -	10 "
Total	254½ feet

## PLIOCENE MARINE SEDIMENTS

Pliocene accumulations are typically marine calcareous sandstones almost identical with outcrops along the banks of the River Torrens near Adelaide. They represent the thin overlapping remnants of a Pliocene littoral.

Near Marino the bed is exposed in a small waterfall 35 feet above sea level. Fossils are poorly preserved and represented largely by casts. The bed is horizontally disposed, outcropping close to the main Marino block fault and at a lower level than at Hallett Cove, due probably to drag effects.

About half a mile north of Black Cliff the bed reappears with glacial erratics concentrated at its base. It continues south as a thin outcropping subhorizontal band (not exceeding four feet) approximately 100 feet above sea level. The bed is highly leached, and consequently fossils are represented largely by casts, but local well preserved patches are to be found. Characteristic of this horizon is the giant foraminifera *Marginopora vertebralis*.

Segnit recorded marine Pliocene to the south of the "Sugar-loaf" in the "amphitheatre," but the occurrence is much more limited than he indicates. Segnit appears to have diagnosed the outcropping unfossiliferous white fluvio-glacial clays and sands (late Palaeozoic) both here and in the cliffs immediately south of Hallett Creek as Pliocene.

The relation of the Pliocene to the underlying glacial and fluvio-glacial deposits varies considerably, at times being distinctly unconformable (as seen in Waterfall Creek north of Black Cliff), and at others disconformable.

Pliocene overlap to the south does not re-occur until near the sea-stack south of Curlew Point. From here a bed of typically leached arenaceous limestone up to 5 feet in thickness can be traced to the north side of Morphet Vale Creek. This horizon does not reappear until Blanche Point is reached.

## POST-PLIOCENE SEDIMENTS

## MARINE FORMATIONS

(a) (?) *Pleistocene Calcareous Sandstone*

The occurrence along the block of a shelving sub-horizontal fossiliferous sandy limestone averaging 250 to 300 feet above sea level is puzzling.

At Hallett Cove the bed outcrops east of the cove, overlying the Brighton limestone at a height exceeding 250 feet above sea level. Here it is often gritty and includes angular to rounded quartz grains, and in the basal portions pebbles of purple slate and quartzites. For the most part the rock is destitute of fossils, but near the base is a limited variety of fossil impressions and casts.

Other occurrences appear further south. The first is indicated by floaters on a ploughed field (Sections 621 and 622) north of Morphet Vale Creek. It outcrops again along a well-defined north-south ridge three-quarters of a mile west of Hackham. It is at least 40 feet thick and the base was not found. No fossils were discovered in these latter localities, but the character of the rock is unmistakable. It reappears near the 300-foot level on the Clarendon-Ochre Cove Block, two miles north-east of Noarlunga.

Howchin (1923, p. 289) recorded the occurrence of the bed at Hallett Cove, and correlated it with the typical Pliocene outcropping at the 100-foot level in Hallett Cove. Segnit included this outcrop in his map, but did not recognise it as fossiliferous.

The author considers the bed to be Post Pliocene, as firstly it overlies mottled clays which normally overlie the Pliocene; secondly, the most common fossil yet recorded is *Tellina lata* (see Howchin 1923). This has not been found in the undoubted Pliocene nearby, and although other fossils are only recognisable

generically, the suite is not typically Pliocene. Thirdly, the altitude does not correspond with the Pliocene horizon, and the amount of pivoted displacement from the horizontal undergone by the bed since its deposition shows that it is Post Pliocene (see section on Block Faulting). The only marine beds with which it can be correlated satisfactorily are the Pleistocene raised beaches of Ooldea and Naracoorte (300 and 250 feet above sea level respectively).

(b) *Late Pleistocene or Recent*

A fossiliferous boulder conglomerate occurs infrequently along the wave cut platform north of Black Cliff. The fossils are typically Recent. North of Hallett Creek, at high tide level, wave action is eroding a fossiliferous calcareous sand dune rock which may be a raised sea beach remnant.

#### TERRESTRIAL FORMATIONS

(a) *Pleistocene Mottled Series*

The erosion of Oligocene and Miocene formations in the north has resulted in the deposition of an extensive blanket of rewashed sediments on the southern extension of the block. Difficulty was experienced in attempting to separate the Oligocene fresh water series from their rewashed equivalents; there is only a gradation.

Oligocene sediments south of Coromandel Valley appear to be dominantly sands, but this is only partly true; the sands are concentrated at the surface ("lag" sands), and the original sediments consist of both sands and clays. The latter has been removed to lower levels in the south, diminishing progressively in grain-size. Clays dominate at the coast. Grain size also tends to decrease vertically, so that at Moana the cliff section reveals silts below clays. In addition coarser sediments (sands) have accumulated against the Clarendon-Ochre Cove block fault. These sands are largely denudation products of the Oligocene series once present on the latter block. On Section 643 they include much talus from the same source.

These Post Pliocene sediments are grey-white or greenish when fresh, but on weathering appear mottled pink and grey, due to the diffusion of iron oxides from centres of incipient ferruginization. The sandstones are commonly well bedded as seen in railway cuttings between Reynella and Morphett Vale. The south bank of Happy Valley Reservoir consists of consolidated mottled sands and clays overlying Oligocene clays unconformably, contributing a source of weakness when the reservoir water level is high, hence Basedow (1904) recorded seepages to the south.

Mottled sediments overlie the marine Pliocene and underlie the high level Pleistocene raised sea-beach, but they are not restricted to that short interval. In fact, erosion of Oligocene sediments and block faulting (early Kosciusko Period) had already passed maximum severity before deposition of the marine Pliocene (fig. 3). Rewashing of Oligocene and Miocene sediments continued throughout the Pliocene and Pleistocene to the present day, depositing the mottled sediments throughout.

North-west of Hackham, Miocene *Turritella* marls are covered by considerable accumulations of waterworn quartz pebbles in sands and clays. These gravels were transported and resorted from the base of the Oligocene series once present on the Clarendon-Ochre Cove block.

(b) *Recent*

The map prepared is dominantly "solid" and therefore drift is not indicated very extensively. Alluvium is not present in sufficient amount to obscure important

geological features, and the use of "floaters" and of numerous wells and bores has overcome many difficulties. Although drift is thick near the eastern block fault, the fault has been traced satisfactorily.

The Tapley Hill-O'Halloran Hill locality features humic soils which are remnants of Oligocene sediments. Similar soils occur immediately south of Happy Valley Reservoir.

The River Onkaparinga has extensive flood plains between Noarlunga and Port Noarlunga. Lenticular creek beds are sectioned in the clay outwash cliffs on the western bank of this river at Noarlunga.

#### THE KOSCIUSKO PERIOD FAULTING

In Australia the Pleistocene, Pliocene and probably even the late Miocene were periods of intense block faulting which appears to be still in progress; Dr. Fenner (1931) and others have discussed this broadly.

A series of more or less meridional faults which, in plan, are arched with their convexities directed eastwards, have developed in a zone embracing Adelaide. The Eden-Moana block which like most of the block faulting south of Adelaide is of the hinge type, with downthrow to the south, is delineated by two of these major faults; these are normal and almost vertical and not compression faults as has been suggested.

The Kosciusko faults are simple, whereas the older group are usually compound. Fault zones, where observed, are marked by superb crush breccias, and unlike the Palaeozoic group of normal faults, dip to the west. Evidence suggests that at Noarlunga the new fault line was influenced by previous movement; several older faults, displaying characteristic stressed quartz and drag phenomena, can be observed on the bank of the River Onkaparinga adjacent to the block fault.

Interesting phenomena accompany the Kosciusko system. The north boundary fault (Fenner's Sturt fault) has dragged the older strata down considerably and altered the strike of beds at the Marino Rocks headland, where the sub-horizontal limb of a strong asymmetrical fold structure outcrops along the cliffs. North from the headland the beds pitch north, and south they pitch south.

The change in pitch is also indicated by the line of intersection of regional cleavage and sedimentary lamination. As the Sturt-Marino fault is approached, the pitch of strata flattens (usually within 100 yards or more of the fault), then reverses until maximum north pitch is recorded at the fault. Actual reversion can be observed in the quarry at the foot of Tapley Hill.

The Tertiary overmass has undergone slight fault folding. The Miocene strata has been dragged up against Adelaide Series rocks at angles often in excess of  $25^\circ$ , as can be seen at Moana and north of Noarlunga.

#### *The Age of the Block Faulting*

The discussion which follows is incomplete, referring solely to the Eden-Moana block. Systematic work is in progress to obtain further information of the relative movements of other important blocks in the vicinity of Adelaide.

A graph (fig. 3, B) indicating the varying amounts of south tilting undergone by the Eden-Moana block proves informative. The height above sea level of the base of each of the three Tertiary marine formations has been plotted against distance south of Marino. Compared with the horizontal scale, the vertical component has been greatly exaggerated.

It will be observed that the graph for the Miocene is relatively even. This is in keeping with other known facts. Evidence indicates that Miocene or (?) late Oligocene seas advanced over horizontally bedded lacustrine sediments which have

been deposited on a peneplained surface during the Oligocene period. A depression is indicated in the vicinity of Port Noarlunga; this is the site of the only brown coal occurrence yet discovered on this block.

Of the marine Pliocene, the Marino occurrence, which is the most northerly, has been affected by fault drag movements. Altitude readings taken at the base of this littoral at Hallett Cove and south of Curlew Point are thought to be representative of the degree of tilting that the block has undergone since Pliocene times.

The base of the Pleistocene raised sea beach is also relatively even. Few altitude observations are available, but they are sufficient to postulate the existence of a raised sea beach or sand dunes near an ancient strand line.

When all positive and negative movement of the block in relation to sea level is reduced to a simple hinge type movement about a point in the north (as illus-

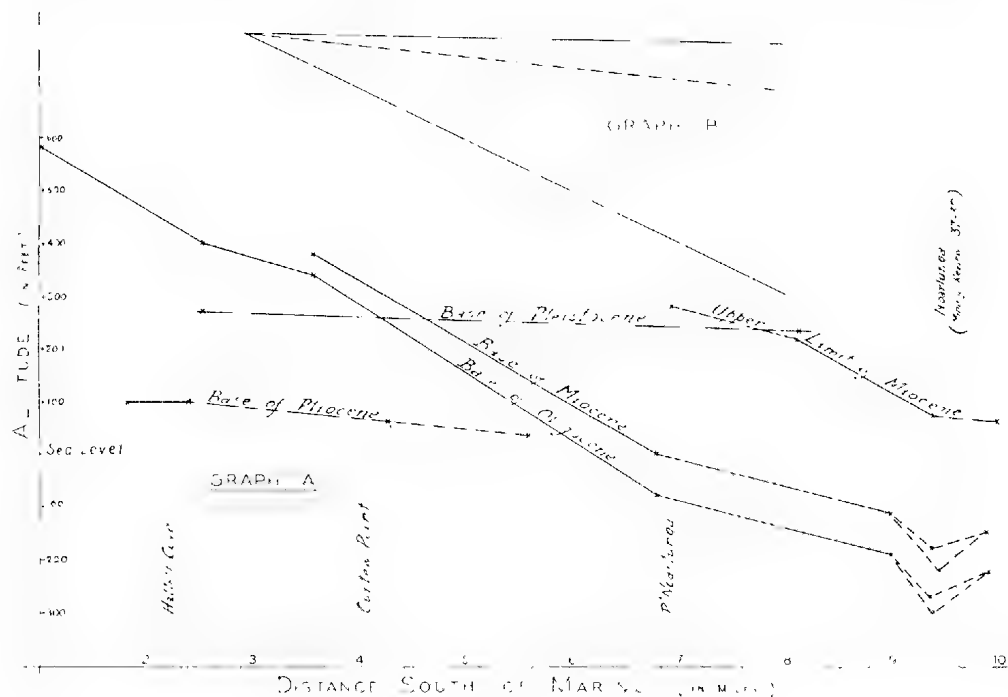


Fig. 3

trated in graph B) the result is interesting. Observations indicate that over a distance of six miles the vertical foundering south (actually partly uplift in the north, but that does not affect the discussion) is 550, 80 and 25 feet respectively for the marine Miocene, Pliocene and Pleistocene formations.

Assuming that the basal portions of the Miocene formation and the Pliocene and Pleistocene littorals were deposited near sea level, then the relative uplift and subsidence can be traced at several well-defined intervals in Tertiary history. Possible eustatic movement of sea level is considered only when dealing with the Pleistocene and Recent raised sea beaches.

Miocene and even late Oligocene seas transgressed the Oligocene peneplain over much of Southern Australia. On the Eden-Moana block more than 200 feet of Miocene beds were deposited over Oligocene lacustrine sediments. Conditions during this period were quiescent, as is shown by the absence of observable unconformities or breaks in sedimentation.

As indicated by the graph, late in the Miocene or in the very early Pliocene, the beds were raised above sea level, then faulting, accompanying the foundering to the south, began. It was strongly pivotal and appears to continue to the present day. Most adjustment occurred prior to the deposition of marine Pliocene. This minor transgression of the sea upon the land was restricted to the present coastal area. The block was then uplifted relative to sea level, resulting in a small hiatus in the marine record until the land was again invaded by sea in the Pleistocene.

Tilting of the block continued on a greatly reduced scale during the Pleistocene so that an extremely small angular nonconformity which can only be observed over a considerable distance exists between the bases of the newly-deposited Pleistocene littoral and the Pliocene. The marine Pleistocene is tilted only slightly to the south and is between 250 and 300 feet above sea level, but whether this altitude is the result of block movement or a negative eustatic movement of the sea since the time of deposition is not proved. The latter appears to be more correct. The suite of included fossils, the height above sea level, stratigraphical relations and the very minor amount of tilting, suggest strongly that the bed is the equivalent of Pleistocene raised sea beaches at Naracoorte and Ooldea, which are respectively 250-300 and 300 feet above sea level. Corresponding raised sea beaches occur in other parts of the world (see Tindale 1933), so that a negative eustatic adjustment of sea level since that time can be reasonably inferred.

A second raised sea beach just above the existing sea level occurs in Hallett Cove. North of Black Cliff, recent fossiliferous boulder conglomerates occur on the wave-cut platform, which is itself a remnant of the higher sea level period. A stranded line of coastal cliffs at Seacliff and the occurrence of *Arca* (*Anadara*) *trapezia* in sand dunes at the rear of Moana beach illustrate the former higher sea level. This series of raised sea beaches just above sea level resultant upon eustatic movements of the ocean in the present waning ice age, is a consistent feature of the Australian coast.

#### ECONOMIC

Little mineralisation has taken place in Adelaide Series rocks in this area, although quartz reefs occur in many fault fissures. The galena zone, developed poorly in the vicinity of Adelaide, has not extended above the Glen Osmond Clay Slates (*e.g.*, the Glen Osmond Mines and Mount Malvern Mine west of Clarendon). Nor is there any notable concentration of barytes in the Purple Series as in the Flinders Ranges and near Noarlunga, although it occurs sporadically in the Brighton limestone at the Brighton quarries as radiating kidney-shaped masses several inches in diameter. Concentric markings and radial structure suggest crystallisation of barium sulphate gels. At Reynella several hundred-weight of wad was collected from Brighton limestone; the occurrence was restricted. Epigenetic fluorite is not common.

The Brighton limestone is used in cement manufacture. High-grade limestone quarried to the west of Reynella is transported by overhead tramway to the cement works near Marino; argillaceous limestone for mixing with the purer limestone is quarried near Marino. Limestones, suitable for cement, were quarried on Mr. Pocock's property to use in building the retaining wall of the Happy Valley Reservoir and in the construction of the main South Road.

Weathering of the dolomitic horizon of the Brighton limestone series has produced a little magnesite.

Alunite is known to occur in the purple slates but not in commercial quantities. Copper was sought in these slates about one mile from the coast in Hallett Creek; none was found.

At Noarlunga Oligocene brown coal deposits have been prospected, but results are not encouraging. For many reasons the deposits cannot yet be exploited

economically. East of Happy Valley Reservoir clear quartz sands and loosely cemented sandstones occur plentifully. These may eventually be useful in glass manufacture.

A sandy glauconite seam several feet thick commonly exists near the base of the marine Miocene, occurring at a depth of approximately 13 feet, south-east of Morphett Vale. Bores also cut the bed to the east of Reynella. As a fertiliser, the glauconite is of fair quality but would not repay mining. Marls form the mass of the Tertiaries, but in composition they are not suitable for the manufacture of cement.

Thick sub-surface travertine was quarried on a small scale south-west of Morphett Vale township for top-dressing cultivated land, but the scheme was unsuccessful.

#### SUMMARY

After a brief survey of relevant geological literature, the physiography of the area is considered. Late Proterozoic and (?) early Cambrian sedimentation is discussed, and special attention is drawn to the perfect completion of a sedimentation cycle following Sturtian glaciation.

In the period succeeding the deposition of the Brighton limestone, conditions existed which resulted in the deposition of a Flysch series of sediments. This is a "red bed" or purple series and has apparent tuffaceous affinities. In the consideration of this series Segnit's Sturtian tillite horizon at Hallett Cove is rejected as merely being purple slate which has been affected by faulting. Indeed, the majority of his findings fail to correspond with the author's investigations.

Correlation of the succession of strata with that of the Upper Adelaide Series occurring in the Flinders Ranges is attempted, and in general the similarity is marked. Evidence having regard to the reliability of the author's estimate of bed thicknesses is gained from a comparison with Madigan's Willunga scarp log of strata and from other sources. The proximity of Cambrian Archaeocyathinae seaward from Christie Beach North is demonstrated.

Problematica described by David and Howchin from certain horizons are discussed briefly; opinion is expressed that these are inorganic structures, not fossil radiolaria, annelids and crustacea as has been supposed. A few general petrographic descriptions are included.

Contrary to Segnit's assertions folding and faulting is shown to be relatively simple. Also, the geological age of the Upper Adelaide Series is considered briefly.

Permian glaciation at Hallett Cove is described and the existence of a fossil valley indicated; the age of the glacigenes is then discussed. The Oligocene lacustrine series with included brown coals at Noarlunga and fossil wood at Reynella are described, and Howchin's supposed dead river theory is shown as inapplicable to this locality. A discussion of Miocene and Pliocene marine sedimentation follows.

The existence of a raised sea beach between 250 and 300 feet above sea level is postulated. A second raised sea beach occurs at high tide level.

Post-Pliocene mottled sands and clays were principally derived from Oligocene sediments outcropping along the north eastern extensions of the block, and also from the adjacent eastern block.

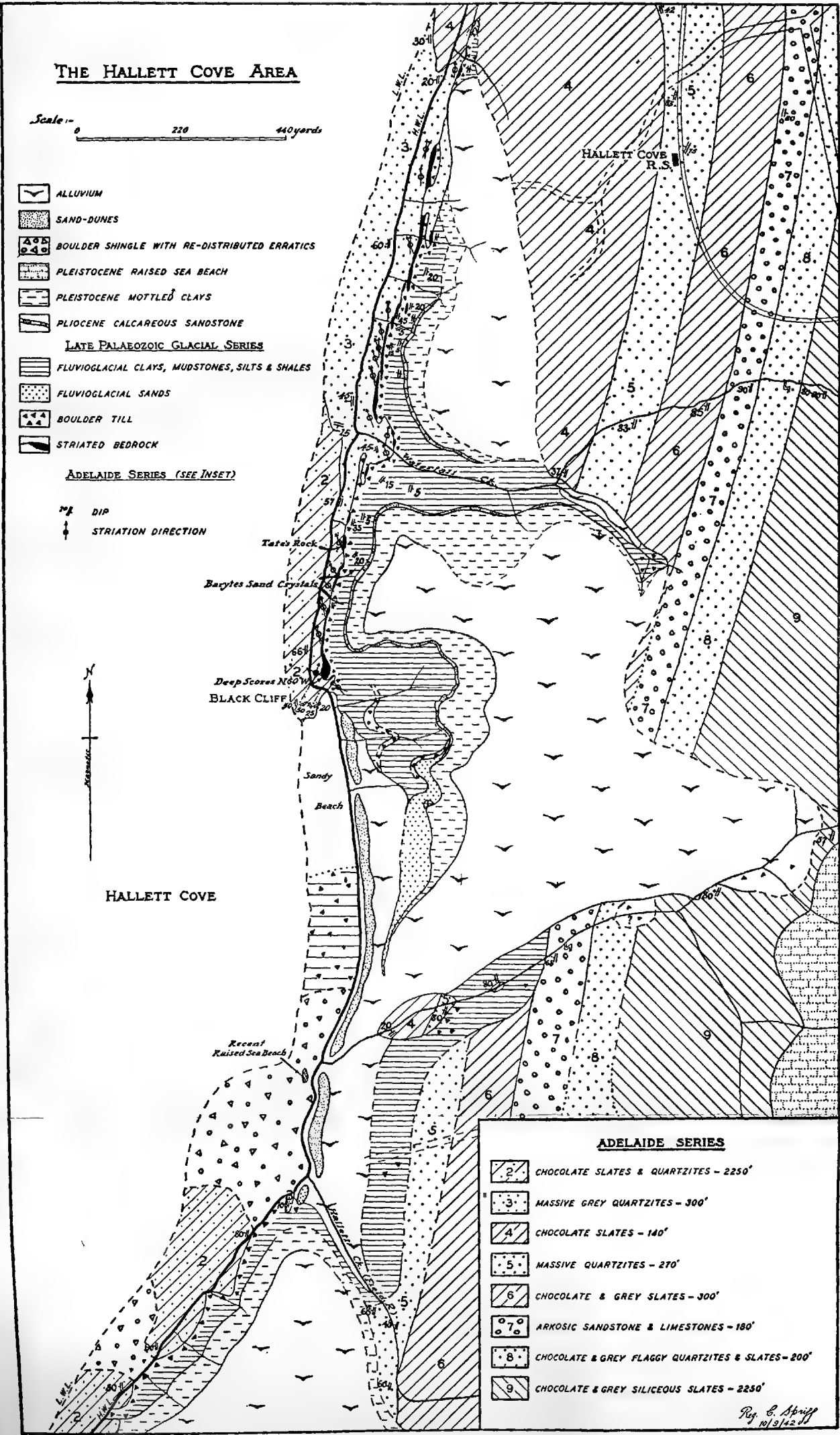
Tertiary block faulting is discussed and the movement of the Eden-Moana segment relative to sea level is demonstrated by means of a graph. The paper concludes with a brief section on economic rocks and minerals.

The map, although necessarily greatly reduced with a consequent decrease in detailed accuracy, was compiled from detailed plans, on a scale of six inches to one mile, which may be seen at the Geology Department, University of Adelaide.

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# **A PRIMITIVE METHOD OF MAKING A WOODEN DISH BY NATIVE WOMEN OF THE MUSGRAVE RANGES, SOUTH AUSTRALIA**

By J. R. B. LOVE (Supt. Ernabella Mission, Musgrave Ranges)

## **Summary**

C. P. Mountford described recently (1) a method of making wooden implements (in his case a spear-thrower) by using unworked stone tools, by men of the Pitjantjatjara (Pitjandjara) tribe from the Mann Ranges in the far North- West of South Australia.

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[Read 8 October 1942]

## PLATES VI AND VII

C. P. Mountford described recently (1) a method of making wooden implements (in his case a spear-thrower) by using unworked stone tools, by men of the Pitjantjatjara (Pitjandjara) tribe from the Mann Ranges in the far North-West of South Australia.

He stated that the tribe had, perhaps, the simplest and most primitive material culture in Australia. He went on to say, from his observations and from information received, that these people could have made satisfactory spear-throwers and carrying dishes with unworked stones similar to those which he figured. Such discarded untrimmed stones would bear no recognisable trace of having been used by man, and it would have been possible for people with a similar material culture to that of the Pitjandjara to have become extinct without having left behind them any recognisable evidence of their culture. The present paper describes the making of a large wooden dish in the neighbouring Musgrave Ranges by native women, using similar unworked implements, thus confirming and extending Mountford's observations.

There are three types of wooden dishes in use in the Musgrave Ranges, namely: (1) the "piti," a water vessel, cut from a bend of a tree—this may contain from one to three gallons; (2) the "wira," a small scoop or shovel, used for digging in the earth, to make the sleeping hollow for the night camp, for scooping up hot ashes in cooking, for digging for water in sandy creek beds, and for digging graves; (3) the "kanilpa," the winnowing dish, similar in shape to the "wira," but larger, used for winnowing grass seed, for separating cooked "jalka" bulbs from ashes, and also as a container for fruits and berries.

All three types may be spoken of as "piti," though usually the term "piti" signifies a water vessel. The large water "piti" is also named "minpa." The "wira" is alternatively named "pata," and the "kanilpa" alternatively named "wini." The name "kanilpa" is derived from the verb "kauini" meaning winnow. The water vessel "piti" is, obviously, concave in both longitudinal and transverse sections; the "wira" and "kanilpa" are flat in longitudinal section and concave in transverse section.

The process of manufacture for the three vessels is the same, the water container being cut from a bend, the other two types from a straight tree trunk. The timber used is the white-stemmed gum (*Eucalyptus rostrata*).

A convenient opportunity to witness and describe the manufacture of the dish recently occurred when a tree was felled for a post. The trunk proved to be hollow, a mere shell, of no use for the purpose for which it was cut. One of the native men remarked that it was a good tree for a "piti."

Nowadays the dish is usually cut from the tree with a steel axe, but when volunteers were called for to cut a dish by means of stones only, there was an immediate response and a laughing party of half a dozen women, headed by a woman of some fifty years of age, undertook to make a dish. A search was made for sharp-edged stones, to act as axes. Several of these weighed about six pounds

each, and one or two not less than ten pounds. Each woman placed a stone on her head and walked off to the sandy bed of the creek, where the tree was lying.

Two women took up positions on opposite sides of the tree trunk, and each with a rather light stone of several pounds weight, marked out on the green bark of the tree trunk the size of the dish to be cut (fig. 1). These two then chopped and chipped at one end of the dish until they had sunk a groove through the outer sap wood (fig. 2). The sharp edges of the axe stones soon wore out, and not a few of the stones broke after a few blows. Some were re-shaped by striking off rough flakes from the edge; others were at once discarded.

After the first impression had been made with lighter stones, heavier stones were used, being lifted with both hands and good stout blows struck, until the hard wood below the sapwood was cut through and a hole actually appeared in the trunk of the tree. This was greeted with delight.

The women worked in pairs—as one tired another took her place. One woman worked with an infant in one arm, but did not allow the presence of the little child to prevent her from doing a very good share of the work. After one hour and a half of painful labour the whole outline of the dish had been cut through the sap and hardwood, and the roughly-shaped dish was levered from the rotten core of the tree by means of a stick of a foot or so in length (fig. 3, 4). The green bark was left on the back of the dish till a later stage. The rough dish was now taken to camp and work on it postponed till the next day.

The women all showed their hands, every one blistered and cut from the wielding of the heavy axe stones; but all laughed at their pains. The ages of the women varied from about 20 to 50 years, the oldest taking the leading part, but the youngest being not at all behind in skill and zest. Though they worked cheerfully at this task, one could appreciate the difference that the steel axe has made in alleviating their toil.

The rough dish was buried in wet sand in the creek bed till the following morning, when work was resumed by four women who toiled in turn singly. Still using rough natural stones, the centre was hollowed out until the rotten core and the hardwood were removed, down to the sapwood.

At this stage a manufactured tool was brought into use—the stone adze, named "tjurna" or "tjurninpa." This is a flake of flint mounted with spinifex gum on the end of a slightly curved handle of heavy mulga wood. The handle is about two feet in length by two inches in diameter. This adze is usually regarded as a man's tool; but all of these women were quite proficient in its use. After the rough dish has been chopped out from the trunk of a tree, the finishing stages may be done by men or women. In this case all the work was done by women, with several of the older men as interested witnesses, particularly the old man who provided the stone adze for use. This old man gave frequent hints to the women who were doing the hollowing out, and turned and explained what they were about to do next.

When all the sapwood had been removed the dish was set in a slanting hollow in the earth, concave side uppermost. The woman who was chiselling the centre sat astride the dish and, using the adze in both hands, striking towards her, chiselled out small shavings from the centre of the dish.

When the centre of the dish had been approximately shaped the dish was reversed, the green bark removed, and the back of the dish subjected to further chiselling until the dish was pronounced thin enough.

The adzing, first with natural stones, and then with the manufactured adze, of the centre and back of the dish, took a day and a half of almost continuous labour by four women who worked in turns.





As the adzing neared completion a cooking pit was prepared. A hole was scooped in the earth, big enough to accommodate the dish. Over this a good fire was lit and allowed to burn down to ashes and hot coals. By the time the adzing was finished the fire was ready to receive the dish. As the adzing went on and the sides of the dish became thinner, the edges curled inwards. It was to counteract this that the fire was needed. The completely adzed dish was rubbed all over, inside and out, with a handful of wetted shavings. Coals and ashes were now scooped from the fire pit and the dish placed in the pit, concave side upwards. The back of the dish was next covered with wetted shavings, which were in turn covered with ashes and coals. After being in the fire pit for a quarter of an hour, the dish was taken and beaten clean from hot ashes. Hot coals were now put in the centre of the dish, which was placed on the ground. The woman who had taken the leading part now gradually forced the sides of the dish wide open, by pushing against the far side with one foot and pulling the near edge with her two hands. The dish was pulled into a low concave shape while hot from the fire.

To keep the dish from curling while drying, three transverse sticks were inserted, pressed firmly down into the hollow of the dish and held in place by the tendency of the drying vessel to contract (fig. 6).

The dish was now rubbed over the back with red ochre and pronounced complete.

It measured two feet three inches in length by eleven inches in width.

The first stage of manufacture, that of chopping the rough shape from the tree trunk, took one and a half hours; the remaining stages required one and a half days.

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### EXPLANATION OF PLATES VI AND VII

#### PLATE VI

- Fig. 1 Marking out the shape of the dish by using a small stone.  
 Fig. 2 Chopping through the stem with heavier stones (note stone in the hand of the woman on the left).  
 Fig. 3 Using a stick to prise the roughly-shaped dish from the remainder of the hollow stem (adjacent to the stem are the stones which had been used).

#### PLATE VII

- Fig. 4 The roughly-shaped dish as removed from the log.  
 Fig. 5 Using the stone-bladed adze (tjurna) to trim the dish.  
 Fig. 6 The finished dish (piti or kanilpa), with the three transverse sticks still in position to prevent contraction.
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# **THE MORPHOLOGY OF NANNOCHORISTA MACULIPENNIS TILLYARD (MECOPTERA)**

By J. W. EVANS

## **Summary**

The Mecoptesa, which at the present day comprise one of the smallest orders of insects, are of great interest to students of insect morphology because it is generally accepted that they lie at the base of the evolutionary stem from which have arisen all the holometabolous orders, including the Coleoptera. The order is divided into two sub-orders, the Protomecoptera and the Eumecoptera. One family of the Protomecoptera, the Meropeidae, is represented in the Australian region and four out of the five families of the Eumecoptera occur here. Three of these have a world-wide distribution, whilst one family, the Nannochoristidae, has only been recorded from Australia, Tasmania, New Zealand and Southern Chile.



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The Mecoptera, which at the present day comprise one of the smallest orders of insects, are of great interest to students of insect morphology because it is generally accepted that they lie at the base of the evolutionary stem from which have arisen all the holometabolous orders, including the Coleoptera. The order is divided into two sub-orders, the Protomecoptera and the Eumecoptera. One family of the Protomecoptera, the Meropeidae, is represented in the Australian region and four out of the five families of the Eumecoptera occur here. Three of these have a world-wide distribution, whilst one family, the Nannochoristidae, has only been recorded from Australia, Tasmania, New Zealand and Southern Chile.

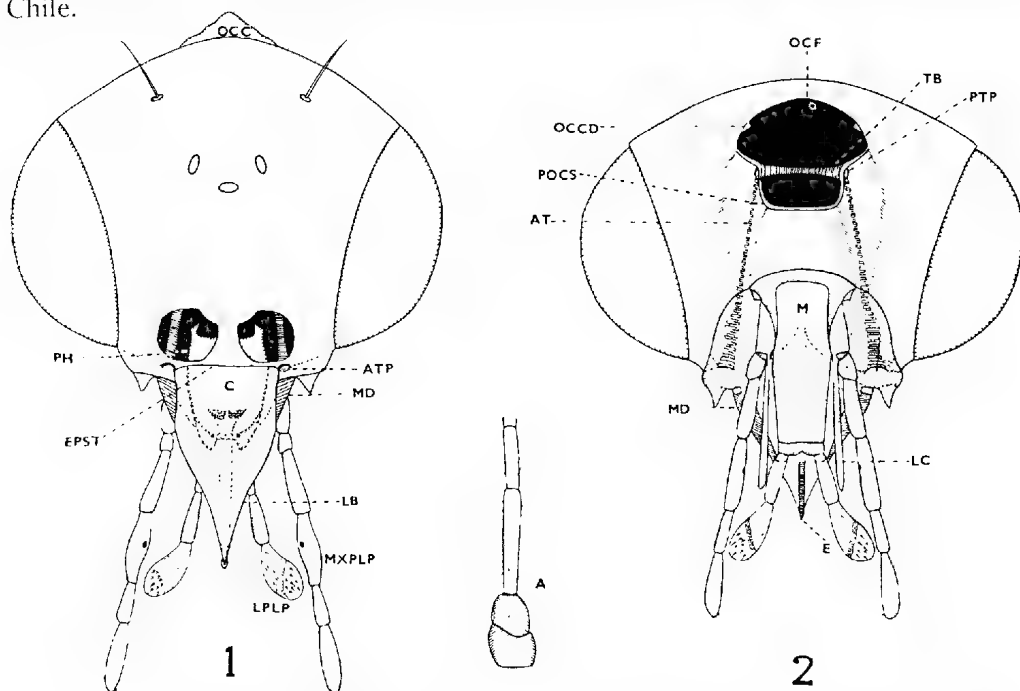


Fig. 1 *Nannochorista maculipennis*—Head in dorsal aspect: A, antenna; ATP, anterior tentorial pit; C, clypeus; EPST, epistomal suture; LB, labrum; LPLP, labial palp; MD, mandible; MXPLP, maxillary palp; OCC, occiput; PH, pharynx. Fig. 2 Head in ventral aspect: AT, anterior arm of tentorium; E, epipharynx; LC, lacinia; M, mentum; OCCD, occipital condyle; OCF, occipital foramen; POCS, postoccipital suture; PTP, posterior tentorial pit; TB, tentorial bar.

The present study, which has been undertaken in order to make better known an archaic though specialised type, has been made possible by the collection of a large number of specimens of *Nannochorista maculipennis* Tillyard. This species, one of the four species of *Nannochorista* so far recorded from Tasmania, was originally described from a single male specimen collected on Cradle Mountain, Tasmania, at a height of 3,500 feet. During February 1941, countless represen-

tatives of *N. maculipennis* were found flying around shrubs, especially *Orites acicularis*, growing at a height of 3,800 feet on Mount Wellington, near Hobart, Tasmania.

Tillyard (1917) thought that the larvae of *Nannochorista* were almost certainly aquatic. This is improbable, and although small pools and streams abound in the shallow, swampy valley where most of the insects were taken, several were also found at a considerable distance from any exposed water surface. It is believed that the larvae inhabit damp moss and that a Mecopterous larva described recently (Evans, 1942) may well be the larva of a species of *Nannochorista*.

#### DESCRIPTION

*N. maculipennis* is a small fragile insect with a wing expanse of about 14 mm. The body is brown in colour and the wings hyaline with brown markings.

#### The Head (Fig. 1-4)

The head is small and globular, the eyes large and three ocelli are present. The antennae consist of twenty-four segments, the two proximal ones being broader and shorter than the rest. Little trace remains of the various cranial

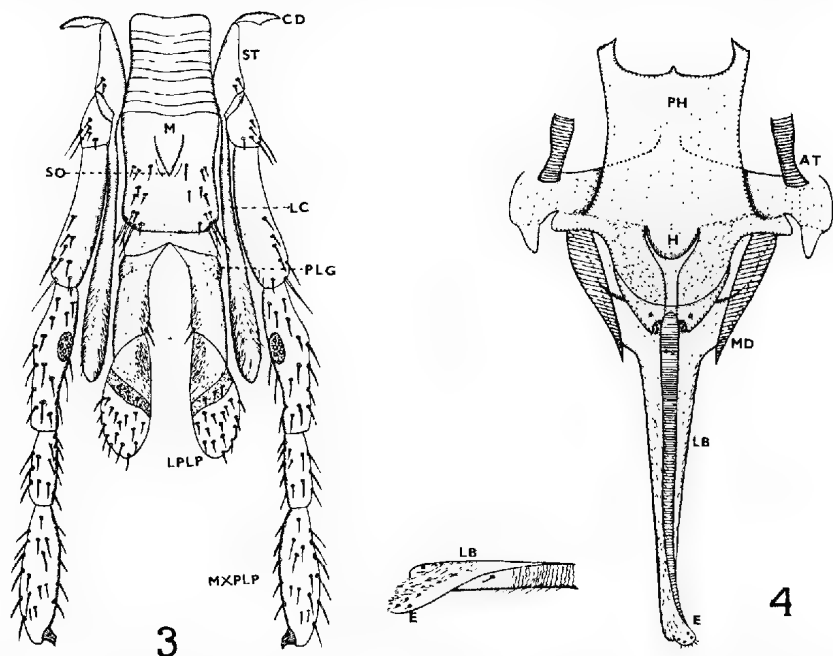


Fig. 3 *Nannochorista maculipennis*—Labium and maxillae: CD, cardo; PLG, palpiger; SO, salivary orifice; ST, stipes. Fig. 4 Anterior part of head of same, viewed internally: H, hypopharynx; other lettering as in previous figures.

sutures. An occipital suture separates off a small triangular occiput and continues ventrally around the occipital foramen, and the epistomal suture lies just anterior to the antennae between the pits of the anterior arms of the tentorium. Indistinct subgenal sutures extend laterally from these pits as far as the eyes on each side. The mandibles are reduced and probably functionless since the adductor and abductor muscle apodemes are suppressed. Each maxilla consists of a small recurved cardo and a narrow stipes from which arises a single process, probably the lacinia.

The maxillary palps are five-segmented; sense organs occur on the third and apical segments. The labium comprises a long, narrow sclerite in contact with the stipes of the maxilla on each side and a pair of palps. The prementum is reduced to a narrow membranous band and a pair of palpigers. The palps, which are convex on their external surfaces and concave internally, have grooves on their inner surfaces lined with forwardly-projecting hairs. The apical segment of each palp, which is larger than the proximal segment, is armed with short strong spines. In life, the palps are not widely separated, as shown in the figures, but are held out in front in contact with each other, below the apposed laciniae. The single plate of the postmentum is believed to represent the mentum; a submentum is not developed. The area between the labium and the occipital foramen consists of a hypostomal bridge and not a gula.

The labrum is long and narrow and together with the epipharynx forms an apically-swollen tongue-like structure. The pharynx is sclerotised anteriorly and trough-shaped. The dorsal surface of the trough, to which are attached dilator muscles that arise on the clypeus, is of thicker consistency than the ventral surface. The hypopharynx arises from the ventral surface of the trough and is a flattened rounded lobe.

*The Thorax* (Fig. 5, 6, 8, 9)

In the description of the thorax which follows, Ferris' (1939) interpretation of thoracic structure is adopted.

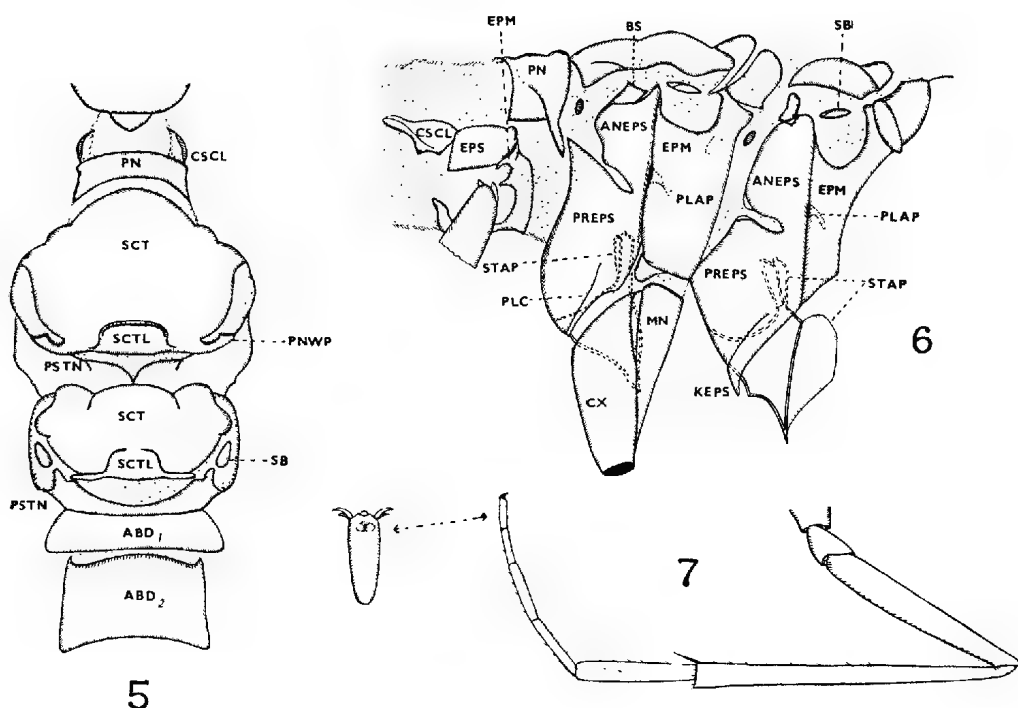


Fig. 5 *Nannochorista maculipennis*—Thorax in dorsal aspect; ABD, abdominal segment; CSCL, cervical sclerite; PN, pronotum; PNWP, posterior notal wing process; PSTN, postnotum; SB, subalar sclerite; SCT, scutum. Fig. 6 Thorax of same in lateral aspect; ANEPS, anepisternum; BS, basalar sclerite; CX, coxa; EPM, epimeron; EPS, episternum; KEPS, kataposternum; MN, meron; PLAP, pleural apodeme; PREPS, preepisternum; PLC, pleural costa; STAP, sternal apophysis. Fig. 7 Hind-leg of same.

The prothorax has a well-developed notum, a small episternum and a reduced epimeron. A pair of apophyses which arise from pits on the prosternum extend to and are attached to the epimeron. The mesothorax and metathorax so closely resemble each other that separate description is unnecessary. Each is divided dorsally into a large scutum, a small scutellum and a narrow postnotum. Laterally, the episternum is partially divided into three distinct areas comprising a dorsal anepisternum, a median preepisternum and a narrow ventral katepisternum. The preepisterna and katepisterna of the two sides are infolded mid-ventrally at the discriminial line and a pair of large apophyses, fused medially but free proximally and distally, arise from the apposed katepisterna. These apophyses represent all that remains of a true sternum. The epimera are undivided, a coxal meron is developed and no trace remains of a trochantin.

The forewings and hindwings resemble each other in size, shape and venation. Each forewing has a single jugal bristle and each hindwing three frenular bristles. The legs are long and have five tarsal segments of which the proximal segment is considerably the largest. There are two pairs of thoracic spiracles situated as shown in fig. 6, and eight pairs of abdominal spiracles.

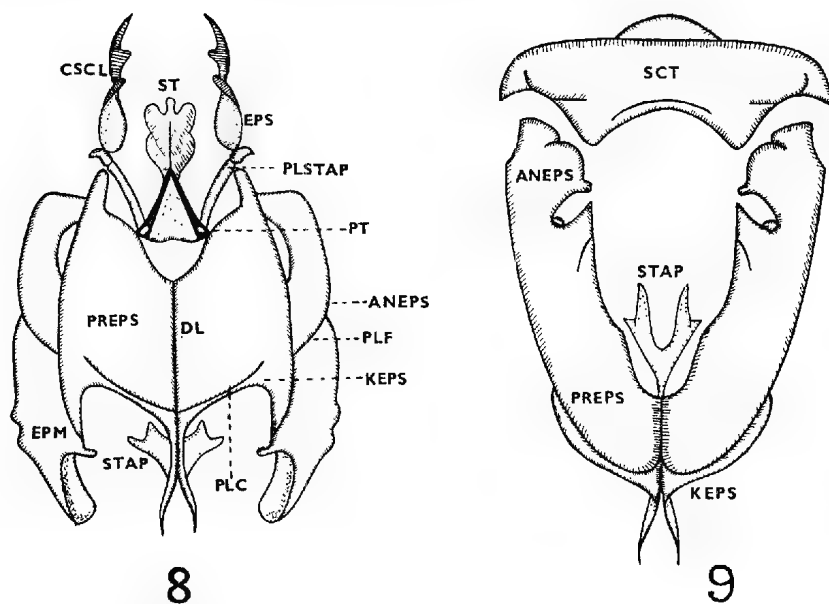


Fig. 8 *Nannochorista maculipennis*—Prothorax and mesothorax, ventral aspect: DL, discriminial line; PLF, pleural fold; PLSTAP, pleuro-sternal apophysis; other lettering as in fig. 5 and 6. Fig. 9 Mesothorax of same, anterior aspect—Lettering as in previous figures.

### The Abdomen

♂ (fig. 12)—The apical abdominal segments of the male consist of a well-developed seventh segment divided into a tergite and sternite, a reduced eighth segment consisting of a complete ring, and a still more reduced ninth segment, also a complete ring. A pair of ventrally-fused bulbous coxopodites arise from the ninth segment, to which are attached a pair of inwardly-toothed harpogones or styles. The phallus, which comprises a median aedeagus covered by a hood-shaped structure, and a pair of ventral lobes, is sunk within the cavity of the coxopodites. The tenth segment is a small complete ring and bears a pair of one-segmented cerci which lie on either side of the eleventh or anal segment. The anal segment consists of distinct dorsal and ventral plates.

♀ (fig. 11)—The female genitalia are of a simple type. The eighth segment bears a pair of ventral lobes which partially overlap the ninth segment; a pair of small laterotergites occur on either side of these lobes. The sternite of

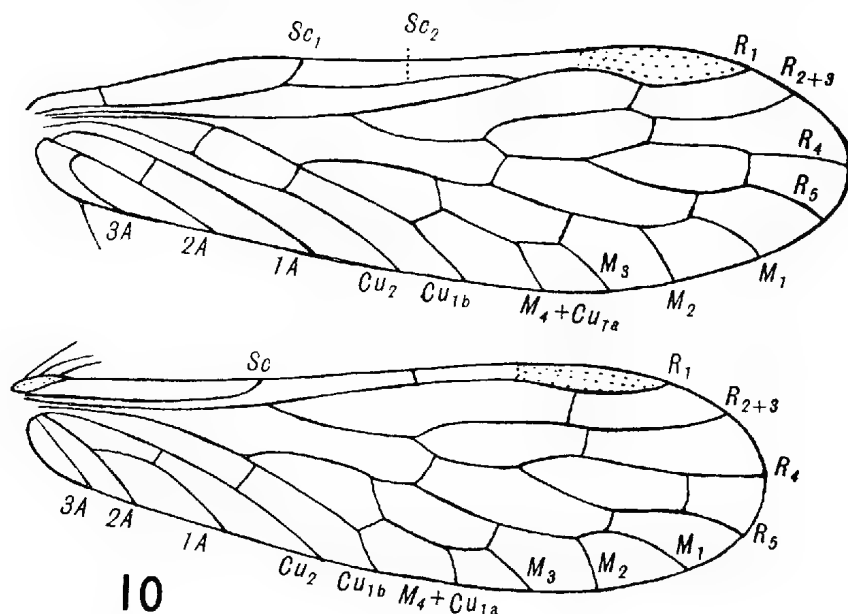


Fig. 10 *Nannochorista maculipennis* Fore and hind-wings

the ninth segment is divided into two narrow processes. The tenth segment consists of a complete ring, and the anal segment which lies between the cercal bases, as in the male, consists of separate dorsal and ventral sclerites. The cerci are well developed and two-segmented.

#### COMPARISON WITH OTHER MECOPTERA

The head of *Nannochorista* differs from those of *Panorpodes*, *Panorpa*, *Boreus*, *Bittacus*, *Apterobittacus* and *Merope* as figured by Otanes (1922) and from the heads of *Apteropanorpa* and *Harpobittacus* in size, being considerably smaller, in shape, being globular, not elongated, and in certain structural features. Species in the genera mentioned above are carnivorous insects with well-developed mandibles. *Nannochorista* feeds by suction or rather "sipping." In most Mecoptera the clypeus and labrum are distinct, the former often being as much as four or five times the length of the latter. In *Nannochorista* the labrum is longer than the clypeus and no external sutures serve to indicate the limits of the two sclerites. The elongation of the head in other genera has resulted in the arching of the subgenal sutures; in *Nannochorista* the subgenal sutures are more or less in a line with the epistomal suture and close to the base of the mandibles. It is uncertain whether the mandibles are entirely functionless, but at the most they can only serve to form part of the walls of a sucking tube. In other Mecoptera the mandibles are elongated and toothed and equipped with strong muscle apodemes.

In having a single process instead of two, the maxilla differs from that of related genera. Otanes considered the divided process of the Mecopterous maxilla represented a divided galea, Ferris and Rees a galea and a lacinia, or at least a

divided lacinia. As the only type examined which displays any tendency to a reduction of either lobe is *Apteropanorpa*, in which the outer lobe is very small and weak, and the inner lobe resembles in shape and appearance the process of *Nannochorista*, the latter is assumed to be the lacinia.

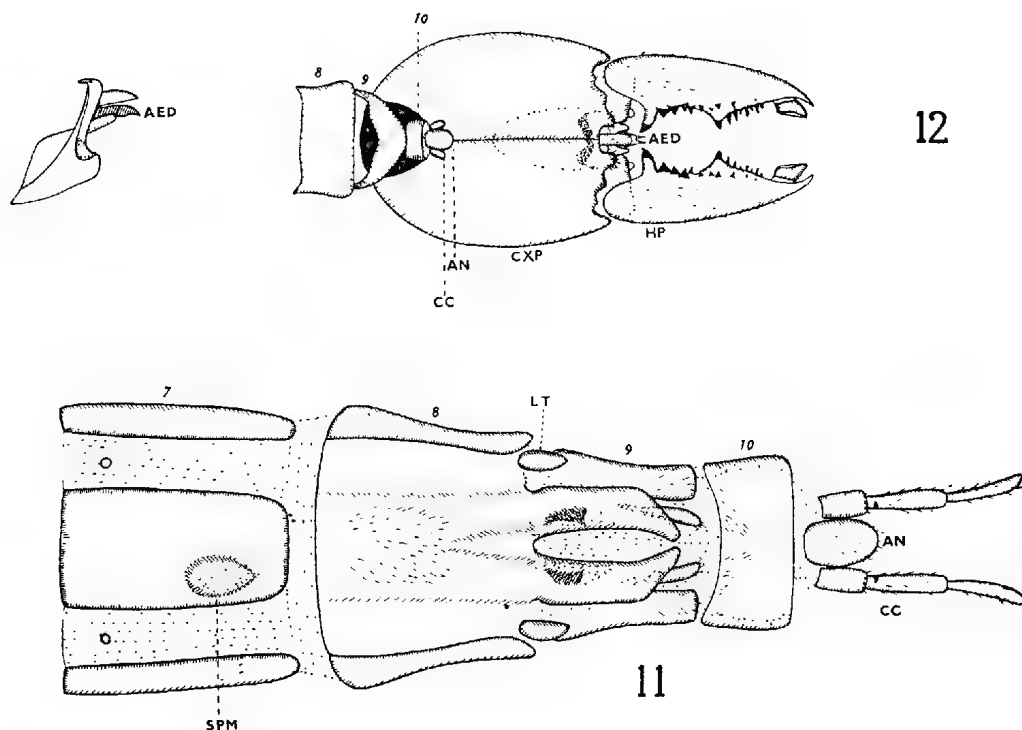


Fig. 11 *Nannochorista maculipennis*—Apical abdominal segments of female: AN, anal segment; CC, cercus; LT, laterotergite; SPM, spermatheca. Fig. 12 Male terminal segments—AED, aedeagus; CXP, coxopodite; HP, harpogone; other lettering as in fig 11.

In most Mecoptera the labium consists of a small wide basal sclerite, the mentum, followed anteriorly by a narrow partially-divided plate, the prementum, also a pair of two-segmented palps of which the proximal segments are larger than the distal ones. Such a condition is found in *Apteropanorpa tasmanica* and is well illustrated for *Panorpa nuptialis* by Ferris and Rees. In these species there is also a large submental area overlying a pair of labial apodemes that arises from the base of the prementum. In *Nannochorista* the prementum is represented only by a narrow membranous area and a pair of palpigers. Tillyard originally (1917) considered the labial palps to be paraglossae, later (1926), he recognised their true identity. The sclerotisation of the dorsal wall of the pharynx anteriorly, in conjunction with the development of a sucking pump, is more marked in *Nannochorista* than in other Mecoptera, though it is probable that such a development occurs to some extent in all representatives of the order.

The tentorium is of the normal type for the group though in *Apteropanorpa* the pits of the posterior arms are situated at the ventral corners of the occipital foramen and not midway along the sides. It is almost certain that the elongation of the clypeus and the consequent wide separation of the mouth-parts from the head-capsule, such as occurs almost universally in the Mecoptera, is a secondary development from the condition retained in *Nannochorista*. Nevertheless, although

the head of *Nannochorista* can be considered primitive in this respect, in other characteristics it is extremely specialised.

The thorax of *Nannochorista* closely resembles those of *Panorpa nuptialis* figured by Ferris and Rees, and of *P. consuetudinis* illustrated in Snodgrass (1937, fig. 99). The only significant difference lies in the development of a pleural cleft in the mesothorax which separates the anepisternum from the preepisternum almost as completely as in the Neuroptera. The retention of jugal and frenular bristles on the wings, which are suppressed in most families, is a characteristic the Nannochoristidae shares only with the Choristidae. So far as the venation is concerned, the only unusual feature is the partial fusion of the media and the first cubitus.

Tillyard (1935) recognised three types of genitalia, the very reduced Meropid type; the Bittacid, which he considered the most primitive existing type, and the Panorpid or bulbous type. The male genitalia of *Nannochorista* belong to the bulbous type but differ from others in this group in the structure of the ninth abdominal segment, the tergite and sternite of which do not partially conceal the coxopodites. The female genitalia are more complete and less specialised than those of certain other Mecoptera, as they retain a pair of gonapophyses on the eighth abdominal segment and have separate cercal bases.

#### COMPARISON WITH THE DIPTERA

It has been claimed (Tillyard, 1937) that the nearest approach among the Mecoptera to the type of Dipterous head-capsule and mouth-parts is to be found in the Nannochoristidae. Further, that the archaic Blepharocerid *Edwardsina* Alex., which like *Nannochorista* has an Antarctic distribution, is the representative of present-day Diptera most nearly related to *Nannochorista*.

An investigation of the head-structure of *Edwardsina tasmaniensis* Tonnoir (fig. 13-15) discloses that there are only two cephalic characteristics shared by *Nannochorista* and *Edwardsina* which are not also possessed by other Mecoptera.

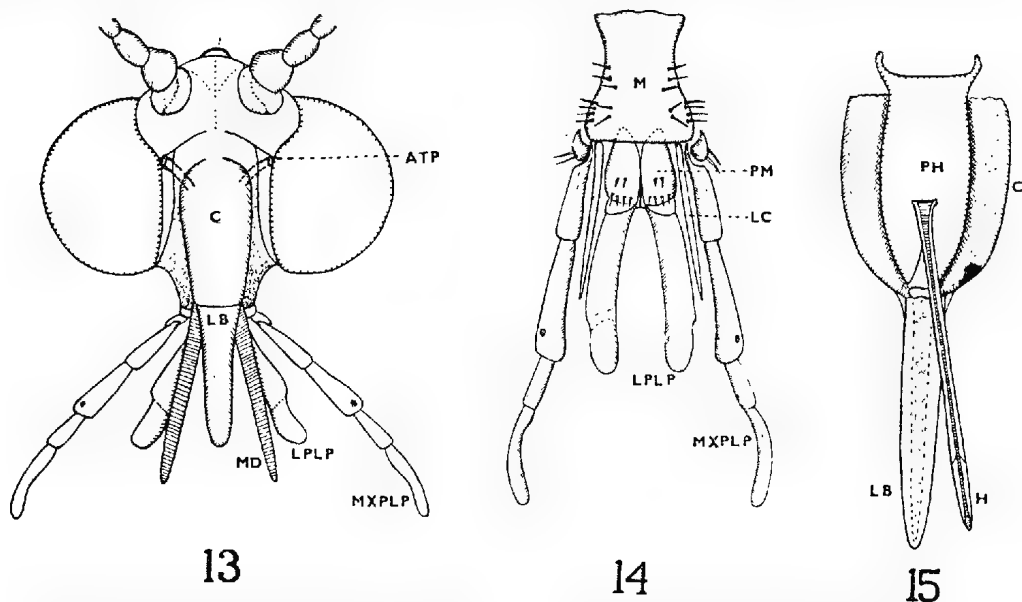


Fig. 13-15 *Edwardsina tasmaniensis* (♀): 13, head; 14, labium and maxillae, PM, prementum; 15, anterior part of head, viewed internally. Lettering as in previous figures.

These are the single maxillary lobe and the presence of a sense-organ on the third segment of the maxillary palps. Among the characters which *Edwardsina* has in common with the majority of Mecopterous genera are a sclerotised pharynx, a postmentum consisting of a single plate, the mentum, two-segmented labial palps, the suppression of glossae and paraglossae and narrow elongated mandibles. The prementum of *Edwardsina* resembles that of all Mecoptera except *Nannochorista*.

The head of *Edwardsina* differs from that of Mecoptera in the position of the clypeus and in the great elongation of the hypopharynx. It is probable that these characteristics are related to each other, as it is evident from the arching of the subgenal and epistomal sutures in *Edwardsina* that the clypeal position is a secondary development. This development may have resulted from the increased pull of the dilator muscles of the sucking pump on the inner surface of the clypeus which followed the change in the function of the mouth-parts that accompanied the elongation of the hypopharynx.

Several Diptera possess a single maxillary lobe, and if Rees and Ferris (1939) are correct in regarding this lobe in Tipulids as the lacinia, and Snodgrass correct in regarding the maxillary process of Tabanids as the galea, then the Diptera must have arisen from a Mecopterous type possessing both a lacinia and a galea. A comparison of the head of *Tipula reesi* as figured by Rees and Ferris with the head of *Panorpa nuptialis* figured by Ferris and Rees, discloses that these two insects resemble each other more closely than do *Edwardsina* and *Nannochorista*. Both have a long narrow clypeus which lies anterior to the eyes and a distinct labrum, also the hypopharynx of *T. reesi* is suppressed, not enlarged as in *Edwardsina*. It is therefore suggested that *Nannochorista* is not so closely related to the Diptera as the other Mecoptera which have an elongate head.

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# TREMATODES FROM AUSTRALIAN BIRDS

## I CORMORANTS AND DARTERS

By T. HARVEY JOHNSTON, University of Adelaide

### Summary

The earliest record of the presence of trematodes in Australian birds was by Krefft (1873), who reported *Distomum* spp. from two species of herons and from a coot from Eastern Australia. The first paper describing flukes from our birds was that published by S. J. Johnston (1904) giving an account of three species of *Holostomum* (from a gull, tern and heron, respectively) and two of *Hemistomum* (from a black swan and *Dacelo*, respectively), all of these having been obtained in New South Wales. T. H. Johnston (1910; 1912) referred to various bird parasites under broad generic terms, e.g., *Echinostomum* and *Monostomum*. S. J. Johnston followed on (1913) with an account of two new species from North Queensland and a record of two already known species. In the following year Nicoll (1914 a; 1914 b) published two papers dealing with parasites from Northern Queensland birds, the first describing seven new species and recording one already known elsewhere, the second paper including eleven new species and four previously known elsewhere. In 1916 T. H. Johnston issued his census of the endoparasites recorded from Queensland animals, including birds (1916).

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[Read 8 October 1942]

### INTRODUCTION

The earliest record of the presence of trematodes in Australian birds was by Krefft (1873), who reported *Distomum* spp. from two species of herons and from a coot from Eastern Australia. The first paper describing flukes from our birds was that published by S. J. Johnston (1904) giving an account of three species of *Holostomum* (from a gull, tern and heron, respectively) and two of *Hemistomum* (from a black swan and *Dacelo*, respectively), all of these having been obtained in New South Wales. T. H. Johnston (1910; 1912) referred to various bird parasites under broad generic terms, e.g., *Echinostomum* and *Mono-stomum*. S. J. Johnston followed on (1913) with an account of two new species from North Queensland and a record of two already known species. In the following year Nicoll (1914 a; 1914 b) published two papers dealing with parasites from Northern Queensland birds, the first describing seven new species and recording one already known elsewhere, the second paper including eleven new species and four previously known elsewhere. In 1916 T. H. Johnston issued his census of the endoparasites recorded from Queensland animals, including birds (1916).

Next year S. J. Johnston published the most extensive paper that has yet appeared relating to flukes from Australian birds. It included the description of twenty-one species of trematodes and gave a list of recorded species (1917). The latter portion of this paper (p. 251-253) contains some errors and omissions which have been carried over into the work of later authors. He omitted to list *Notocotylus attenuatus* from *Anseranas semipalmata*, *Burhinus grallarius* and *Lobivanellus lobatus*; *Opisthorchis obsequens* from *Hieracidea orientalis*; and *Patagifer bilobus* from *Carphibis spinicollis*, these records having been published by Nicoll (1914), all from North Queensland; also *Patagifer bilobus* recorded from *Ibis molucca* by T. H. Johnston (1916) from Southern Queensland. *Strigea flosculus*, reported by Nicoll (1914) from *Podargus strigoides*, was listed by Johnston (1917, 253) under *Dacelo gigas* and omitted from its proper host. *Hemistomum triangulare* (= *Adenodiplostomum triangulare*) whose true host is *Dacelo gigas*, was placed under *Ninox maculata* in addition. It might be mentioned that these errors relate to three host species which follow each other in S. J. Johnston's list, and may have been due to accidental transposition of the lines during typing. He also referred (p. 251) to *Hemistomum triangulare* "parasitic in *Dacelo gigas* and *Ninox maculata* in New South Wales." In reply to my query, Professor E. A. Briggs of the Zoology Department of the University of Sydney, a member of the late Professor S. J. Johnston's staff, informed me that he could not locate any specimens of trematodes from these two hosts amongst the collections belonging to that department. The hosts are not related and they have different food habits. The record of *Adenodiplostomum triangulare* from *Ninox maculata* and *Strigea flosculus* from *Dacelo gigas* (which latter record Dubois (1938) has listed, following S. J. Johnston) should be deleted until corroborated.

Next year T. H. Johnston (1918) identified specifically the various trematodes which he had previously (1910, 1912, 1916) indicated under broad generic names. In 1921 Miss Chase described a Strigeid from a heron. Next year

Cleland (1922) published a paper which contained, amongst other parasites, a list of trematodes recorded from Australian birds, but as this was stated to have been based on S. J. Johnston's paper (1917), it includes the same errors as the latter's work. It was not till 1928 that the next contribution relating to our subject appeared, when T. H. Johnston described three species from *Gallinula*,

Dubois in 1937 (1937 a, 1937 b) published papers in which were described some Strigeids from Australian birds, and in his excellent monograph of the Strigeata (1938) he dealt with all known Australian species (except one) of the group. He included one of S. J. Johnston's erroneous references (p. 71, 480) relating to *Strigea flosculus*, and wrongly listed *Cardiocephalus musculosus* (Johnston 1904) under the Caspian tern, *Hydroprogne caspia*, whereas its host was *Sterna bergii*, the crested tern (p. 116, 481). In passing, it may be mentioned that Dubois in his monograph omitted mention of *Tetracotyle tiliquae* Nicoll. This metacercaria was obtained from the lizard, *Tiliqua scincoides*, and its adult stage will probably be found in an Australian hawk.

Miss Young (1939) published a list of helminth parasites recorded from Australia. Internal evidence indicates that her recording did not take cognisance of work published after 1937, in fact several papers which appeared in that year were omitted. The list is not critical and frequently the same host appears in two different places, since little attempt seems to have been made to give cross references to synonymy of hosts or parasites. The following records of parasites have been omitted: *Catantropis gallinulae*, *Echinostoma australe* and *E. bancrofti* described by T. H. Johnston (1918) from *Gallinula tenebrosa*; *Opisthorchis obsequens* by Nicoll (1914) from *Hieracidea orientalis*; and *Patagifer bilobus* recorded by T. H. Johnston (1916) from *Ibis molucca*. *Echinostoma australasianum* Nicoll is referred to as *E. australium* (p. 61).

In 1940 Miss Goss described two species from Western Australian cormorants. In the same year Johnston and Simpson gave an account of the life history of the bird trematodes, *Leucochloridium australiense* (1904 a) and *Cyclocoelum jaenschii* (1940 b). Next year Johnston and Angel described the life history of *Diplostomum murrayense* from terns (1941 a), *Pelasiger australis* from grebes (1941 b), and *Echinostomum revolutum* from various Australian ducks and the black swan (1941 c). An account of the life history of *Paryphostomum tenuicollis* from cormorants was published recently (Johnston and Angel, 1942).

The only records of the presence of trematodes in domesticated birds in Australia are: (1) *Prosthogonimus oratus* (an error for *P. pellucidus*) by T. H. Johnston (1910, 116), based on a report by Spencer on the occurrence of trematodes in the egg of a domesticated fowl in Victoria (Proc. Roy. Soc. Vict., 1, 1888, 109); (2) *Echinostoma revolutum* from domestic ducks in Queensland by Roberts (1934, 5; 1939, 6). I now record *Echinoparyphium recurvatum* Linst. from a turkey in Melbourne (coll. Dr. A. W. Turner). The pigeon was proved to be capable of experimental infection with *Echinostoma revolutum* in Adelaide (Johnston and Angel, 1941 c).

I have been unable to trace the types and other material belonging to the avian species described by the late Professor S. J. Johnston in 1904. At that time he was economic zoologist to the Sydney Technological Museum. Mr. T. C. Roughley of that institution and Professor E. A. Briggs of the University of Sydney have not been able to locate them for me. Types of species described in S. J. Johnston's papers published in 1913 and 1917 are in the collections of the School of Public Health, Sydney (formerly the School of Tropical Medicine, Townsville, North Queensland), and the Australian Museum, Sydney, respectively. Nicoll's types (1914) were deposited in the former institution. All my early collections of trematodes were handed over to S. J. Johnston for study and formed part of the material described by him in 1917.

I desire to acknowledge assistance received from the Commonwealth Research Grant to The University of Adelaide; from Messrs. G. & F. Jaensch and L. Ellis of Tailm Bend, South Australia, for supplying local cormorants; to Dr. M. J. Mackerras and her father, the late Dr. T. L. Bancroft, for some material from Queensland; to Professor E. A. Briggs for the loan of S. J. Johnston's serial sections of *Echinochasmus tenuicollis* and *Clinostomum australiense*; and to Dr. A. B. Walkom, Director of the Australian Museum, Sydney, for the loan of the type slides of the two species, just referred to, and that of *Dolichosaccus solecarius*.

#### TREMATODES FROM CORMORANTS AND DARTERS

There are five species of cormorants occurring in Australia, *Phalacrocorax carbo* (*novae-hollandiae*), *P. sulcirostris* (also known as *P. ater*), *P. melanoleucus*, *P. fuscescens* (*leucogaster*; *gouldi*), and *P. varius*, the last-named being restricted to coastal regions. *P. melanoleucus* appears to be by far the most common species occurring along rivers and swamps. Trematodes have been obtained from all these species, as well as from the only Australian species of darter, *Anhinga novae-hollandiae*.

Four species of trematodes have been described from Australian cormorants: (1) *Echinochasmus tenuicollis* S. J. Johnston 1917; (2) *Dolichosaccus solecarius* S. J. Johnston 1917; (3) *Paryphostomum phalacrocoracis* Goss 1940; and (4) *Diplostomum granulosum* Goss 1940; the first two were collected in New South Wales and the remainder from the Swan River, Western Australia. *Clinostomum australiense* S. J. Johnston 1917 was described from a Queensland darter. As a result of the present study, numbers (1) and (3) are placed as synonyms of *Paryphostomum radiatum* (Duj.); (2) has been assigned to a new genus, *Dolichosacculus*; and (4) has been found to be a synonym of *Hysteromorpha triloba* Rud. The occurrence of *Petasiger exaeretis* and *Echinoparyphium phalacrocoracis* in various Australian cormorants is now recorded, and a new species of *Stictodora* is described. Additional species have been collected, but their study is postponed for the present.

Miss Goss (1940) gave a brief account of an immature trematode found in *Phalacrocorax varius* from the Swan River. She considered it to belong probably to the Steringophoridae, and to be a parasite of some fish eaten by the bird. It seems to be a member of the Azygiidae near *Azygia*.

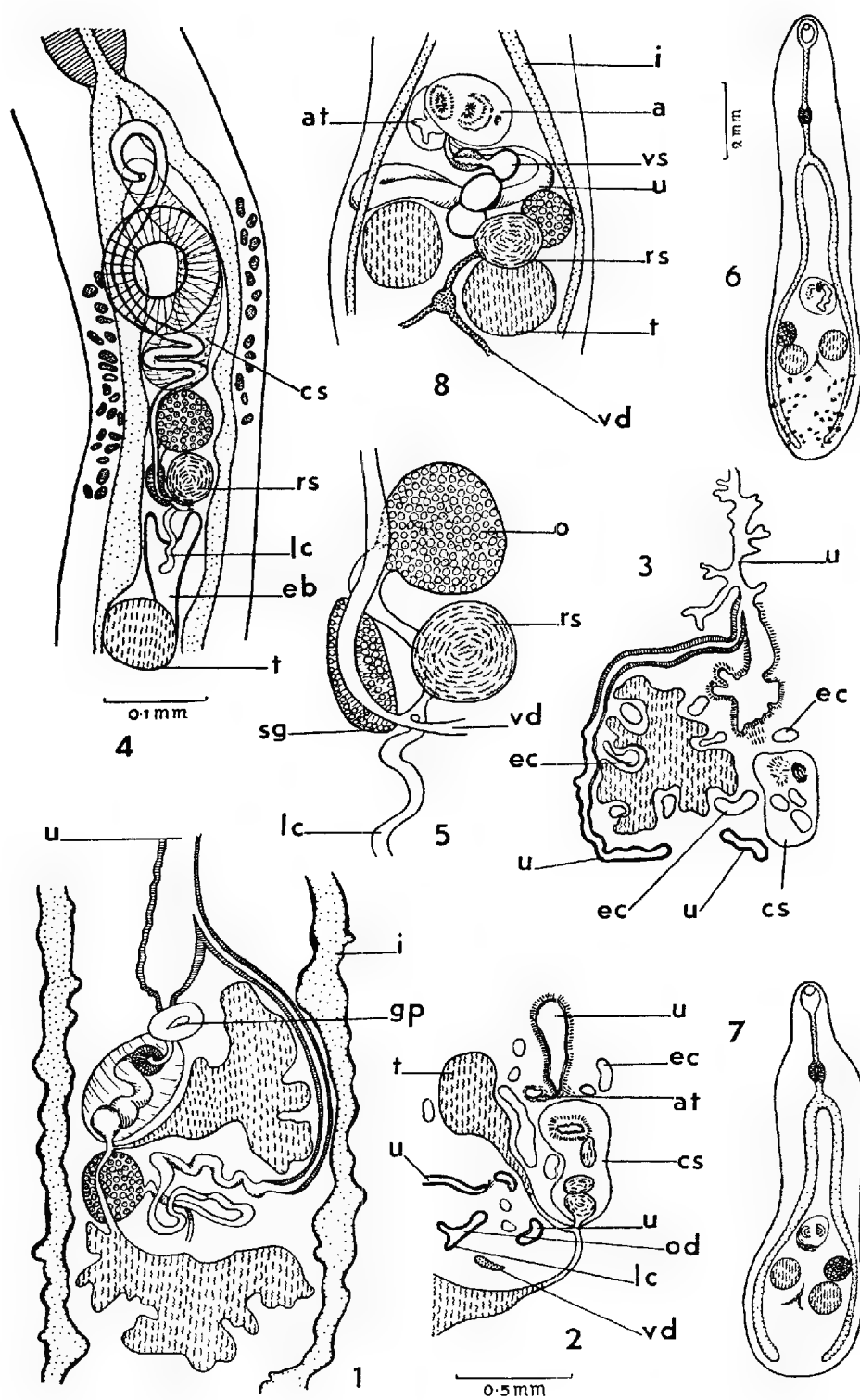
#### CLINOSTOMUM AUSTRALIENSE S. J. Johnston

(Fig. 1-3)

This species from the oesophagus of a darter, *Plotus* (= *Anhinga*) *novae-hollandiae* from Eidsvold, Burnett River, Queensland, was described and figured by S. J. Johnston (1917, 230-234, fig. 17). An examination of the type slide and

Fig. 1-3 *Clinostomum australiense*: 1, genital system (from S. J. Johnston's type); 2, part of L.H. Sect. to show relation of male ducts; 3, part of L.H. Sect. to show relation of uterus to other organs. Fig. 4-5 *Dolichosacculus solecarius* (from S. J. Johnston's type): 4, reproductive system, ventral view, only anterior vitellaria shown, cirrus sac and acetabulum indicated by dotting; 5, sketch, ventral view of female system. Fig. 6-8 *Stictodora diplacantha*: 6-7, entire worms, various organs omitted; 8, reproductive system, most of uterus omitted, dorsal view. Fig. 1, 2, 3 drawn to scale beside fig. 2; 4 and 8 to scale below 4; 6 and 7 to scale beside 6.

a, acetabulum; at, atrium; cs, cirrus sac; eb, excretory bladder; ec, excretory canal; gp, genital pore; i, intestine; lc, Laurer's canal; o, ovary; od, oviduct; rs, receptaculum seminis; sg, shell gland; t, testis; u, uterus; v, vitellaria; vd, vitelline duct; vs, vesicula seminalis.



serial sections has been made. Length, 11 mm.; maximum breadth (in the region of the gonads), 3.25 mm. The sucker ratio is nearly 1:2.

The excretory system is much more extensive than the figure indicates, and its ramifications extend from the extreme anterior to the extreme posterior end. The main canals and loops are well indicated in the original figure. The bifurcation of the very short terminal portion of the bladder lies very closely adjacent to the ends of the crura. Yamaguti (1933, 67, 69, and fig. 28), in his account of *C. complanatum* from Japanese *Nycticorax*, mentioned that the crura each opened into the excretory bladder. A study of longitudinal horizontal sections of *C. australiense* revealed the presence of a thin membrane separating the termination of each crus from the base of the corresponding arm of the bladder. Canals belonging to the excretory system are abundant in the tissues surrounding the testes, ovary and sex ducts. The caeca have very numerous short irregular diverticula. Gland cells are very abundant in the pre-acetabular region, both intra-caecally and extra-caecally.

The anterior testis is somewhat triangular and lies mainly on the left side. It measures about .66 mm. across its base, and .71 mm. in length. It is almost surrounded by the uterus and cirrus sac. Its vas deferens arises from the inner posterior corner as a thin-walled tube which travels nearly transversely to join the other vas deferens immediately before entering the cirrus sac. The posterior testis is transversely elongate and much lobed and extends almost from one crus to the other. Its maximum breadth is .95 mm. and length .45 mm. Its vas deferens arises from the part of the gland which lies just behind the ovary and travels more or less directly anteriorly to the cirrus sac. The vasa lie ventrally from the ovary. The cirrus sac is elliptical with broadly rounded ends, measures .66 mm. in length by .33 mm. in breadth and lies slightly obliquely on one side of the midline. Its posterior end is almost in contact with the ovary. It contains a wide twisted vesicula seminalis. The cirrus is short and provided with prominent blunt conical spines. There is a well marked genital atrium receiving the uterine aperture anteriorly, while the short male canal from the cirrus sac enters it on the opposite side. The genital pore is median and lies just behind the level of the front border of the anterior testes.

The ovary is almost circular in outline, being about .3 mm. in diameter. It lies directly behind the cirrus sac. The oviduct issues from the mid-region of its inner surface and curves anteriorly and then posteriorly and inwardly. Mehlis' gland is inconspicuous. The main yolk duct enters the oviduct in its vicinity. Laurer's canal is an obvious structure in sections and terminates on the dorsal surface just in front of the level of the anterior border of the posterior testis. Yolk glands are scattered but are restricted, probably because of immaturity of the specimens, to the region in the vicinity of the posterior testis. The uterus is thrown into a number of short curves as it travels forwards from the ootype, making two transverse loops and then a longer third one just behind the anterior testis. It passes around the outer border of the latter on a more ventral level than the crus, and then curves inwards and forwards in front of the testis to enter the median uterus at a very acute angle. Johnston's figure of the uterus in the vicinity of the genital pore is not quite correct. The median uterus or uterine sac is thin-walled with muscular fibres, and has numerous short diverticula in the immature specimens examined. The sac extends forwards to a point distant behind the acetabulum equal to the length of the latter. The posterior portion of the sac is widened and then becomes constricted to join the atrium by means of a narrow muscular uterine canal.

Johnston has pointed out the chief differences between *C. australiense* and *C. marginatum* Rud. which is widely distributed in North and South America in

Ardeiform birds, its metacercaria occurring as cysts in various fresh water fish. The position of the uterus is more like that in *C. attenuatum* than that in *C. marginatum* and *C. complanatum* (Cort 1913). The only other known Australian species is *C. hornum* Nicoll 1914 from Ardeiform birds in North Queensland. The latter is probably a synonym of *C. complanatum*, as Yamaguti (1933, 71) has suggested.

***Dolichosacculus solecarius* (S. J. Johnston 1917) n. gen.**

(Fig. 4-5)

This species is known from a single immature specimen taken from *Phalacrocorax melanoleucus* from Tuggerah, New South Wales. It was described and figured as *Dolichosaccus solecarius* by Johnston, but some details were not referred to adequately. As a result of an examination of the type slide, some additional structures have been seen.

The excretory bladder can be traced forwards as a rather wide tube above the two testes, almost to the region of the shell gland, where it bifurcates to terminate in two short broad arms ending at about the level of the middle of Mehlis' gland. It thus resembles that of *Opisthioglyphe*. The anterior margin of the pharynx bears four prominent rounded lobes. The oesophagus is practically absent.

Just behind the rounded ovary is the thin-walled spherical receptaculum seminis containing a number of ova, its diameter being .42 mm. The oviduct arises postero-laterally from that part of the ovary which lies in front of the shell gland and travels back dorsally above the latter and part of the receptaculum. The shell gland lies laterally from the receptaculum and from the region just behind and between the two arises Laurer's canal which travels posteriorly in a sinuous course to terminate dorsally. A yolk duct can be seen joining the oviduct just before the latter enters the shell gland. The uterus, after leaving the shell gland, becomes thrown into a few short closely-arranged loops between the ovary and the posterior end of the acetabulum and immediately below the vesicula seminalis. It then crosses below the posterior portion of the cirrus sac, travels forward beside the latter, but on the opposite side, and then appears to be thrown into a wide loop below the anterior half of the cirrus sac. It continues forwards and, in front of the sac, it curves back to end at the female pore. The tracing of the course of the uterus has been difficult because of the extreme thinness of its walls, its unstained condition, and the absence of eggs. The cirrus and the terminal portion of the female duct are similar in their relations to those figured by Travassos (1930; fig. 24) for *Dolichosaccus rastellus*.

The systematic position of the species has remained uncertain. S. J. Johnston included it in his genus *Dolichosaccus* with some doubts, stating that it differed from the three known species, all of them from Australian frogs, in its cylindrical form, in the relative sizes of the two suckers, and in the topography of the vitellaria. The latter, in species from amphibians, are not restricted to the zone below and laterally from the crura but are widely distributed and occupy a broad post-ovarial zone; they also extend much further forward than in *D. solecarius* and may reach the level of the pharynx. The genus as originally diagnosed would include *D. solecarius*, except for the distribution of the yolk glands. Though Johnston stated that it was doubtful whether a receptaculum seminis was present in species of the genus (1912, 309), his type, *D. trypherus*, as figured by him (fig. 4), shows the presence of such an organ which he called a "fertilization space," and he actually called the organ a receptaculum seminis in his fig. 5 (*D. trypherus*), fig. 7 (*D. ischyryus*) and fig. 8 (*D. diamesus*). He regarded *Dolichosaccus* as being close to *Opisthioglyphe*. He placed it in the Plagiorchinae (1912); 1917).

Perkins (1928) allocated the genus to the Telorchhiinae. He included it in his key to the subfamily and regarded the species described from Australian frogs as validly included in it and (p. 353) incorporated them in his key. He went on to state that another species placed in the genus, *D. parvula* Johnston (*sic*) 1916, was known only by a single very young specimen (from a bird, *Phalacrocorax*), which had an exceedingly short uterus containing only one large egg and which therefore should probably be removed to the Psilostominae. He did not include it in his key to species of *Dolichosaccus*. Perkins apparently confused S. J. Johnston's specific name, *solecarius*, with Nicoll's *Dolichopera parvula* which is also mentioned in the same paper. Johnston (1917, 220), in his original account, stated definitely that the uterus was short and did not extend back beyond the shell gland and that it contained no eggs. Perkins (1928, 343) thought that *Dolichosaccus* and *Brachysaccus* (both from Australian frogs) were probably not distinct, but an examination of Johnston's figures shows that in the latter the cirrus sac is shorter and lies in front of the acetabulum, Laurer's canal is very much larger, and the uterus is much more extensive, occupying most of the intercaecal space between the ventral sucker and the testes.

Travassos (1930, 2) when dealing with *Opisthioglyphe* and related genera, placed *Brachysaccus* under the former, and showed that Perkins' *Lecithopyge* was a synonym of *Dolichosaccus*. He gave a diagnosis of the last-named and included the presence of a spermatheca as one of the features (1930, 11). He did not include *D. solecarius* in the genus as he considered that its occurrence represented a case of accidental parasitism of the cormorant by a young specimen of a fish trematode near *Podocotyle* (Allocreadiinae), young flukes being more easily able to adapt themselves temporarily in a new host. In this connection it is of interest to mention that Miss Goss (1940) recorded the finding of an immature trematode, regarded as belonging to the Steringophoridae, in *Phalacrocorax varius* from Perth, Western Australia. The specimen was believed (no doubt correctly) to belong to a species infesting fish. Her account and figure suggest a member of the Azygiidae, such as *Azygia* sp., rather than a Steringophorid.

Mehra (1931, 175) allocated both *Dolichosaccus* and *Brachysaccus* to the Telorchhiinae, placing the former (in his diagram) between *Cercorchis* and *Brachysaccus*. In a later paper (1937) he retained *Dolichosaccus* in that subfamily.

From the foregoing statements it will be seen that *D. solecarius* has been variously assigned. The appearance of the specimen suggests a member of the Telorchhiinae, but the position of the uterus resembles that of many Allocreadiids. The form of the excretory bladder allocates the parasite to the Plagiorchioidae, so that membership of the Allocreadiidae can be definitely excluded.

The parasite from *Phalacrocorax* differs especially from typical species of *Dolichosaccus* in the distribution of the yolk glands. These are restricted to the vicinity of the caeca between the level of the ventral sucker and the end of the caeca and located especially laterally from the caeca, but they extend to lie ventrally to the latter, leaving the intercaecal field free from them.

The differences from *Dolichosaccus* may be best expressed by regarding *D. solecarius* as representing a new genus, *Dolichosacculus*, with the following characters: Telorchhiinae; characters as in *Dolichosaccus* except that the body is more or less cylindrical and the vitellaria are restricted to the caecal and extra-caecal regions behind the mid-acetabular level. Type *D. solecarius* (S. J. J.) from *Phalacrocorax melanoleucus*. The genus is close to *Dolichosaccus* and *Opisthioglyphe*.

The systematic relationships of *D. solecarius* suggest that its presence in a cormorant may be accidental and that its true host may be a frog, since all known species of *Dolichosaccus* and *Opisthioglyphe* occur in frogs. It may be mentioned



that the cercaria of a very common trematode, *Paryphostomum radiatum*, widely distributed in Australian cormorants, can infect tadpoles and thus reach its meta-cercaria stage (Johnston and Angel, 1942).

#### PARYPHOSTOMUM RADIATUM (Duj.) Dietz

*Distomum (Echinostoma) radiatum* Dujardin 1845.

*Paryphostomum radiatum* Dietz 1909; 1910; Lühe 1909; Edwards 1927.

*Echinochasmus tenuicollis* S. J. Johnston 1917; T. H. Johnston 1918.

*Paryphostomum testitritifolium* Gogate 1934.

*Paryphostomum phalacrocoracis* Goss 1940.

*Paryphostomum tenuicollis* Johnston and Angel 1942.

*Paryphostomum testritifolium* Goss 1940, 5-6 (error for *testitritifolium*).

The first Australian reference to the parasite was that by S. J. Johnston who described it as *Echinochasmus tenuicollis* (1917, 206), the host being *Phalacrocorax melanoleucus* from New South Wales. He stated that the 19 dorsal spines were arranged in an uninterrupted row and varied little in size; the testes were three-lobed; the uterus little coiled; and the vitellaria terminated anteriorly some distance behind the ventral sucker. I identified it (1918, 212) from the same host species from the Thompson River, Western Queensland, and drew attention to the extension of the vitellaria as far forward as the level of the posterior edge of the acetabulum, as well as to the more anterior position of the male and female glands than was indicated in the original figure.

A recent examination of my material indicated that the species did not belong to *Echinochasmus* but to *Paryphostomum*, and it was under the name *P. tenuicollis* that the account of its life history and an extended host list were published by Johnston and Angel (1942). In South Australia it was ascertained that its molluscan hosts were the pond snails, *Amerianna pyramidata*, *A. pectorosa* and *A. tenuistriata*. It is probable that any Australian species of *Amerianna* (*Physa*, *Eulinus* and *Isodora* of Australian authors) would be able to serve as the molluscan host. The cyst stage was obtained experimentally in five species of aquarium fish, as well as in the tadpole of *Pseudophryne bibroni*, and was found occurring as natural infections in three species of fish from the Murray swamps at Tailem Bend, South Australia; viz., *Carassius auratus* (golden carp), *Pseudaphritis urvilli* (congolli), and *Tandanus tandanus* (cat fish). The adult stage was recorded from the following species of cormorants in South Australia: *Phalacrocorax carbo*, *P. melanoleucus*, *P. fuscescens*, and *P. sulcirostris* (syn. *P. ater*). The arrangement of the collar spines in a double row was figured and the sizes published.

Miss Goss (1940) described *Paryphostomum phalacrocoracis* from *Phalacrocorax ater* and *P. melanoleucus* from the Swan River, Western Australia, and published a comparative table of various characters and measurements of *P. radiatum* (of Dietz and of Edwards) and *P. testitritifolium* Gogate.

A comparison of the accounts and figures published by Dietz, Edwards, Gogate and Goss indicates that they were all dealing with the same species, since the differences listed are only minor variations. A study of S. J. Johnston's type, as well as of my own material from Queensland, New South Wales, Victoria and South Australia, has permitted me to synonymize *P. tenuicollis* with *P. radiatum*.

A re-examination of the type specimen of *P. tenuicollis*, which is that figured by S. J. Johnston (fig. 5), shows that it is 2.47 mm. long by .59 mm. in maximum breadth (somewhat compressed) and is immature and that the uterus contains only one egg. The latter is undersized, and has a colourless shell and lies adjacent to the shell gland. The structure of the female complex is essentially like that of *P. radiatum* as described by Edwards. The dorsal collar spines are arranged in

two series, those of the more anterior row being very slightly longer than those of the second row, the sizes being respectively  $\cdot 09$  and  $\cdot 088$  mm. The testes are trilobed but the anterior shows the presence of a small fourth lobe in front. The other details regarding its anatomy have been published by S. J. Johnston.

I have already stated that in Queensland material the vitellaria extended forwards to the acetabular level, and that the ovary and testes were situated more anteriorly than was indicated by S. J. Johnston. As a result of an examination of a large number of specimens from various Australian localities, it has been ascertained that the length of egg-bearing worms ranges between 2.4 and 5 mm., the maximum breadth being about one-fifth or one-sixth the length. Longer specimens (up to 5.8 mm. long) were collected, but they were relatively narrower ( $\cdot 6$ – $\cdot 66$  mm.) and in them the uterus was very long and narrow, extending back for 1.43 mm. behind the end of the acetabulum. Such specimens resemble that figured by Miss Goss (fig. 1). Most of our mature worms resembled closely those figured by Dietz and by Edwards.

Two series of collar spines are usually recognisable, especially mid-dorsally, but the interval between the two is generally slight. The sizes fall within the ranges listed by Miss Goss. The following sizes were observed. Spines of the anterior dorsal series measure about  $\cdot 102$  mm. long, those of the second series about  $\cdot 092$ – $\cdot 095$  mm., the shoulder spines about  $\cdot 107$  mm.; the spine next to the group of corner spines,  $\cdot 092$ – $\cdot 097$  mm. (this spine is in series with the posterior dorsal series), the corner spines are unequal in length the ventral inner being about  $\cdot 112$ , ventral outer  $\cdot 105$ , upper inner  $\cdot 118$ , and upper outer  $\cdot 136$  mm., all these measurements being taken from heads lying in glycerin in a favourable position for measuring.

In mature worms the centre of the aperture of the acetabulum lies at about the end of the first fourth or fifth of the body length, while the posterior edge of that sucker is situated at about one-third of the body length from the anterior end of small mature specimens and at about two-fifths in the case of large adults.

The post-testicular region varies in relative length according to the age of the worm, and to some degree so also does the length of the preovarian region (measuring from the front of the ovary to the anterior end of the worm). The former lengthens with age and the latter diminishes. In specimen 1.3 mm. long post-testicular region was  $\cdot 275$ – $\cdot 33$  mm., ratio of the latter to body length 1:4.4–6, preovarian region  $\cdot 75$ – $\cdot 99$ , ratio of the latter to body length 1:1.3–1.7; in a worm 2 mm. long these measurements and ratios were  $\cdot 42$ , 1:4.7, 1:16, 1:1.7; in worms 2.6 to 2.7 mm. long they were  $\cdot 53$ – $\cdot 66$ , 1:4.5, 1:12–1:13, 1:2.3–3; in a worm 2.9 mm. long they were  $\cdot 55$ , 1:5.3, 1:37, 1:2; and in a specimen 3.44 mm. in length they were  $\cdot 99$ , 1:3.5, 1:5, 1:2.3 respectively. All the worms just referred to had not yet reached the egg-bearing stage, though the longer parasites had ovarian eggs in the oviduct and nearly all had sperms in the receptaculum seminis.

In S. J. Johnston's type (which had just entered egg-bearing, the first egg having entered the uterus), the post-testicular region was nearly one-fifth of the body length and the ovary was situated just behind the mid-body.

The longest worm observed which had not yet become egg-bearing was 2.97 mm. long and  $\cdot 44$  mm. wide at the acetabulum, but only  $\cdot 3$  mm. wide at level of the testes, the post-testicular region being 1:4.5 of the body length. It was probably somewhat macerated. The shortest specimens found with one or more eggs in the uterus were 2.4 mm. and 2.47 mm. long. The former had two eggs, poorly developed vitellaria, a postacetabular region 1.3 mm. long, and its post-testicular zone was 1:3.3 of body length. The other worm which was of the same length of the type specimen had six eggs, a postacetabular length of 1.49 mm., and

a post-testicular zone .58 mm. long 1:4). In mature specimens with abundant eggs in a closely coiled uterus the latter occupies 1:3-3.8 of the body length. Miss Goss' figure indicates that in a very narrow worm 6 mm. long the latter region was 1:3.5 of the body length and that the preovarian length was one-eighth of the total. Dietz's figures show the post-testicular zone to be about 2:5 of body length in a worm 5.2 mm. long and 2:7 in one 6.8 mm. long. The testes are very variable in outline and, as stated by Dietz (1910), possess from three to seven or more lobes. The following indicates the conditions seen by us in the anterior and posterior testes respectively, minor lobulations being indicated after the plus sign: 3 + 1, 3; 3 + 2, 3 + 4; 3, 3; 5, 6 + 3; 4, 4; 4, 7; 4, 6; 3, 6.

The vitellaria extend forwards at least as far as the posterior border of the acetabulum in worms which are mature, but in specimens under 3 mm. in length the follicles usually do not reach more than half-way between the front of the ovary and the end of the acetabulum.

Edwards published an excellent account of the female complex. The receptaculum seminis is a conspicuous thin-walled structure appearing at first sight to be spherical, but if it be followed down ventrally it will be seen that it narrows only slightly to join the oviduct while its opposite side becomes somewhat pear-shaped to form eventually a very narrow ootype passing almost directly ventrally through the relatively large "shell gland," receiving the very narrow vitelline duct before entering. The uterus widens suddenly into a tube lying below the axis of the shell gland and then skirting the ovary or passing below it, travels forwards in a few loops which lie close together when the uterus is full of eggs. On reaching the posterior border of the acetabulum the tube becomes only slightly sinuous. The metraterm is well supplied with sphincter fibres. Laurer's canal arises from the receptaculum as a very narrow, rather thick-walled tube which, after a very short course, terminates on the surface above the region of the shell gland. The folded condition of the large vesicula seminalis is shown in Edwards' figure. The extended cirrus measures .43 mm.

The short oviduct is very wide, and tapers rapidly before passing dorsally to become the receptaculum. The latter commonly contains masses of sperms. The transverse yolk duct skirts very closely the posterior edge of the shell gland. The yolk reservoir is usually conspicuous.

The form of, and space occupied by, the uterus vary with the sexual condition of the worm. When immature, it is only slightly sinuous and is relatively long (its course between the front of the ovary and the posterior edge of the acetabulum cup extending for more than one-fifth of the body length in the type specimen). It becomes more and more markedly coiled and folded when filled with eggs, and its course, as indicated above, may occupy only 1:25-35 of the body length. That part of it which lies below the ovary and shell gland has not been taken into consideration in connection with these measurements. There is thus a relative shortening of the postacetabular region occupied by the uterus, and associated with this alteration are the forward extension of the vitellaria and an increase in the length of the post-testicular zone.

S. J. Johnston reported that eggs measured .084 by .058 mm.; Dietz .084-.088 by .054-.061; Edwards .08-.1 by .05-.064; Johnston and Angel .07-.084 by .058-.063. The longest I have measured was .092 by .063.

Amongst the material studied were numerous immature stages. The smallest obtained from cormorants were excysted metacercariae measuring only .28 mm. long by .1 to .12 mm. in maximum width, with the almost hemispherical acetabulum in the posterior third of the body. The size of the metacercarial stage was not mentioned by Johnston and Angel (1942), but their figure indicates a long narrow form, .32 mm. in length, .07 mm. wide at the acetabulum, the latter being .03 mm. wide, .05 mm. long, and situated at mid-length.

The following measurements in millimetres of a series of specimens ranging from metacercariae to worms which had not yet reached the egg-bearing stage indicate the relative lengthening of the acetabulum, and the post-acetabular region in relation to the increasing length of the parasite: (i) total length; (ii) breadth at acetabulum; (iii) length of acetabulum (*i.e.*, from front edge to posterior end of base); (iv) breadth of acetabulum; (v) distance from front edge of acetabulum to head end (*i.e.*, pre-acetabular length); (vi) distance from posterior end of base of acetabulum to end of worm (*i.e.*, post-acetabular length); (vii) approximate ratio of (v) to (vi); (viii) length from centre of aperture of acetabulum to head end; (ix) length from centre of aperture of acetabulum to end of body; (x) approximate ratio of (viii) to (ix).

	i	ii	iii	iv	v	vi	vii	viii	ix	x
1 .	·28	·1	·06	·06	·16	·06	8:3	·19	·09	2:1
2 ....	·46	·13	·12	·10	·19	·14	10:7	·24	·23	1:1
3 .	·51	·17	·13	·11	·24	·13	2:1	·30	·21	3:2
4 ....	·58	·18	·15	·13	·26	·15	5:3	·32	·25	4:3
5 .	·66	·16	·14	·12	·26	·23	10:9	·32	·33	1:1
6 ....	·87	·27	·25	·20	·32	·30	1:1	·40	·47	5:6
7 ....	·88	·23	·15	·15	·31	·52	3:5	·37	·51	3:4
8 .	1·25	·42	·32	·28	·36	·57	5:8	·45	·80	1:1·8
9 .	1·30	—	·33	—	·33	·64	1:2	—	—	—
10 .	1·32	—	·35	—	·44	·88	1:2	—	—	—
11 .	1·32	·35	·30	·27	·43	·57	3:4	·54	·80	1:1·5
12 .	1·80	·40	·38	·32	·60	·80	3:4	·68	1·12	1:1·7
13 .	1·98	—	·42	—	·55	1·43	1:2·6	—	—	—
14 .	2·64	·55	·44	·55	·58	1·54	1:2·6	—	—	—
15 .	2·69	·44	·55	·42	·62	1·54	1:2·5	—	—	—
16 ....	2·91	·53	·55	·42	·55	1·76	1:3·2	—	—	—
17 .	3·44	·55	·58	·41	·66	2·20	1:3·3	—	—	—

*Paryphostomum radiatum* is now known to occur in the following Australian localities (including those now recorded) and species of cormorants: *Phalacrocorax melanoleucus*—Brisbane and Longreach, Queensland; Tuggerah, New South Wales; Gippsland, Victoria; Tailern Bend, South Australia; and Perth, Western Australia. *P. sulcirostris*—Burnett River, Queensland; Glenelg River, Victoria; Tailern Bend and Adelaide, South Australia; Perth, Western Australia. *P. carbo novae-hollandiae*—Burnett River, Queensland; Bathurst, New South Wales; Tailern Bend and Hope Valley, South Australia. *P. fuscescens*—Tailern Bend. The only Australian species from which the trematode has not been obtained is *P. varius*, a cormorant restricted to a coastal habitat. It appears probable that *Paryphostomum radiatum* is a parasite associated with swamps and rivers rather than marine environments.

Dietz (1910) recorded it from *P. carbo* from Central Europe, and Edwards (1927) from the same species from Wales. Yamashita (1938, 1085) reported it from *P. carbo hanedae* from Japan. Yamaguti (1939, 143-4) gave a brief account of specimens from the latter host species, as well as from *P. capillatus*, both from Japan. Gogate's *Paryphostomum testitriifolium*, stated to have been taken from a Burmese tree-duck, *Dendrocygna javanica*, agrees so closely with *P. radiatum* that it should be placed in synonymy.

#### PETASIGER EXAERETUS Dietz

This minute echinostome has been found in *Phalacrocorax carbo* from Tailern Bend, South Australia, and from Bathurst, New South Wales; *P. melanoleucus* and *P. sulcirostris* from Tailern Bend. S. J. Johnston's type slide of *Dolichosaccus*

*solecarius* from *P. melanoleucus* from Tuggerah, New South Wales, contains a specimen of *Petasisiger exaeretus*.

The dimensions and certain other features differ markedly from those given by Dietz (1910) whose material came from *P. carbo* from Europe, but they agree sufficiently closely with the measurements given by Davies (1934) for specimens from *P. carbo* from Wales. The following account is based on specimens from South Australia.

Length 1.2-1.3 mm., but up to 1.76 mm. in worms with very elongated pre-acetabular region; maximum breadth (at the acetabulum) .31-.38 mm.; width of the head collar .23, and of the neck .17-.18. In a worm 1.3 mm. long and .34 mm. in breadth, the gonads were fully developed but no egg was present; while in another of similar dimensions (1.2 mm. long by .35 mm. in maximum width) there were five eggs. The preacetabular region of the body is covered by abundance of scales. The oral sucker is more or less circular, .04-.06 mm. long by .04-.07 mm. wide; the acetabulum is almost circular in outline, .18-.24 mm. wide by .19-.25 mm. long. The ratio of breadths of the two suckers is 1:3-3.5; and of lengths 1:3-5, usually about 1:3. The distance from the anterior border of the acetabulum to the head end of the worm, *i.e.*, the preacetabular length, is approximately half the body length, the ventral sucker lying wholly in the posterior half. The postacetabular length (*i.e.*, measuring from the hinder border of the acetabulum to the end of the worm) is about one-third of the total length. There are 27 spines including the two corner groups, each with four. The larger pair of corner spines are about 75-77  $\mu$  long and the other pair about 60-70  $\mu$ , the width being 12-13  $\mu$ . The first lateral spine is the smallest and narrowest in the series; it measures 35-40  $\mu$  long and may overlap the corner spines. The remaining laterals are 57-65  $\mu$  long, the length increasing as they approach the dorsal surface. The dorsal spines are arranged in two series, those of the anterior series being much shorter (36-42  $\mu$  long) and narrower (4  $\mu$  broad) than those of the second group (45-55  $\mu$  by 6-7.5  $\mu$ ), the shortest and thinnest in the groups being those nearest the mid-dorsal region. All spines are rather pointed, especially the dorsal series.

The prepharynx is about .05 mm. long; the pharynx .076-.08 mm. long by .034-.04 mm. wide; and the oesophagus .27-.3 mm. long. The crura extend almost to the end of the worm.

The testes are tandem, slightly elongate transversely, especially the anterior, the posterior being usually rather narrower and longer than the other. The dimensions are .19-.22 mm. broad by .1-1.15 mm. long. The thin-walled cirrus sac lies somewhat obliquely on one side in the region between the crura and the acetabulum, and extends back above or beside the anterior third of the latter. It measures about .14 by .05 mm. and its posterior half is occupied by the folded seminal vesicle. The genital aperture is immediately behind the intestinal bifurcation.

Davies has given a good account and figure of the female complex. The ovary is about .075 mm. in diameter and lies to one side of the midline. The receptaculum is closely associated with the shell gland and is of about the same size but rather less regular in shape. It lies between the ovary and shell gland, and is approximately in the median line. The course of the uterus is similar to that described by Davies, as also is that of the yolk ducts and yolk reservoir. The yolk follicles do not extend forwards much beyond the mid-level of the acetabulum. They may invade the edges of the testicular field to a slight extent. The arrangement is the same as that given by Davies and unlike that described and figured by Dietz. The uterus is very short, forming a loop in the vicinity of the ovary and then travelling forwards, parallel with the cirrus sac. In some specimens the thicker-walled vaginal portion is greatly dilated into a more or less spherical structure several times the size of the cirrus sac and filled with a darkly-staining secre-

tion. Eggs measure  $\cdot 055\text{--}\cdot 09$  by  $\cdot 055\text{--}\cdot 067$  mm. The maximum number seen in the uterus was nine, but there were usually 1-5.

*Petasisger exaeretis* has been recorded by Dietz from Central Europe and by Davies from Wales, in both cases from *Phalacrocorax carbo*. Yamashita (1938) reported its presence in *P. carbo hanedae* in Japan. Its known range is now extended to include south-eastern Australia.

#### HYSTEROMORPHA TRILOBA (Rud.)

*Distoma trilobum* Rud. 1819.

*Hemistomum trilobum* Dies 1850; Lühe 1909; Krause 1914.

*Proalaria triloba* La Rue 1926; Ciurea 1930.

*Diplostomum trilobum* Hughes 1929; Ciurea 1933.

*Hysteromorpha triloba* Lutz 1931; Dubois 1938; Yamaguti 1939.

*Diplostomum granulosum* Goss 1940.

The only Australian record of this diplostome was that of Miss Goss (1940, 6-7) who described it as *Diplostomum granulosum* from *Phalacrocorax ater* from Perth, Western Australia. I have obtained it from *P. carbo novaehollandiae* from Tailem Bend, South Australia, and Bathurst, New South Wales; *P. melanoleucus* from Tailem Bend, and Glenelg River, Victoria; *P. sulcirostris* (*ater*) from Tailem Bend; and *P. fuscescens* (Tailem Bend). A comparison of the accounts and figures published by Krause (1914), Lutz (1931), and especially those by Dubois (1938), Ciurea (1930) and Yamaguti (1939), with the Australian material and with Miss Goss' account, indicates that *H. triloba* is a very widely distributed species, now being known from *P. carbo* from Austria and Roumania; *P. pygmaeus* from Roumania; *P. auritus* from Minnesota, U.S.A.; *P. brasiliensis* from Brazil; *P. carbo hanedae* from Japan; and from the four Australian species mentioned above.

Eggs from my material measured  $\cdot 085\text{--}\cdot 093$  mm. by  $\cdot 060\text{--}\cdot 068$ , most of them being  $\cdot 087\text{--}\cdot 090$  by  $\cdot 063\text{--}\cdot 065$  mm. Yamaguti gave the dimensions as  $\cdot 092\text{--}\cdot 105$  by  $\cdot 06\text{--}\cdot 069$ ; Goss  $\cdot 086$  by  $\cdot 085$ , but her figures indicate  $\cdot 07\text{--}\cdot 08$  by  $\cdot 07\text{--}\cdot 50$  mm.; Dubois  $\cdot 097\text{--}\cdot 099$  by  $\cdot 052\text{--}\cdot 062$ ; Ciurea  $\cdot 075\text{--}\cdot 099$  by  $\cdot 048\text{--}\cdot 075$  mm. Lutz (1931) and Ciurea (1930; 1933) have published information relating to stages in the life history of the species.

#### ECHINOPARYPHIUM PHALACROCORACIS Yamaguti

This small trematode was described recently by Yamaguti (1939, 142) from the Japanese cormorant, *P. carbo hanedae* and *P. capillatus*. I have collected it from *P. carbo novaehollandiae*, *P. sulcirostris* and *P. melanoleucus* from Tailem Bend. Very few specimens were present on the few occasions that the parasite was obtained.

The narrow body measures  $1\cdot 6\text{--}2\cdot 1$  mm. by  $\cdot 29\text{--}\cdot 22$  mm. in maximum width (at the acetabulum). The head is somewhat pointed,  $\cdot 15\text{--}\cdot 17$  mm. wide, not sharply marked off from the neck which at the level of the pharynx measures  $\cdot 16$  to  $\cdot 2$  mm. There is little variation in width from the region of the genital pore to that of the posterior testis. The oral sucker is nearly spherical, measures  $\cdot 06\text{--}\cdot 08$  mm. long by  $\cdot 06\text{--}\cdot 07$  mm. wide. The acetabulum is  $\cdot 17$  mm. long by  $\cdot 16$  mm. wide and lies at the end of the first third and anterior part of the middle third of the body length. The preacetabular length (measuring from the front edge of the organ) is  $1\cdot 2\cdot 6\text{--}2\cdot 7$  of body length, and the postacetabular length (measuring from the posterior edge of the base of the organ to the end of the worm)  $1\cdot 1\cdot 86\text{--}1\cdot 9$  of body length. The sucker ratio is  $1\cdot 2\cdot 3\text{--}2\cdot 6$  for breadths and  $1\cdot 2\cdot 1\text{--}2\cdot 8$  for lengths. The distance between the centres of the apertures of the suckers is  $\cdot 64\text{--}\cdot 77$  mm., i.e.,  $1\cdot 2\cdot 5\text{--}2\cdot 6$  of body length. The genital pore lies

about  $\cdot 07\text{--}\cdot 14$  mm. in front of the acetabulum and a short distance behind the intestinal bifurcation. There are 27 collar spines, including the two end groups each comprising four. The latter are  $57\text{--}63\ \mu$  long by  $8\text{--}10\ \mu$  wide. The lateral spines are much shorter but vary in length ( $36\text{--}42\ \mu$ ). The dorsal spines are arranged in two distinct alternating series, those of the anterior row being  $25\text{--}29\ \mu$  and those of the second row  $36\text{--}38\ \mu$  long.

The narrow prepharynx measures  $\cdot 075\text{--}\cdot 09$  mm. long; the pharynx  $\cdot 065\text{--}\cdot 07$  mm. long by  $\cdot 05$  mm. wide; and the narrow oesophagus  $\cdot 30\text{--}\cdot 35$  mm. long. The caeca extend almost to the posterior end.

The two rounded testes are arranged tandem and are of approximately the same size,  $\cdot 16\text{--}\cdot 18$  mm. diameter, and lie in the posterior half of the body. The cirrus sac is large, about  $\cdot 17\text{--}\cdot 2$  mm. long by  $\cdot 11$  mm. wide, somewhat obliquely placed behind the intestinal bifurcation and extending back above the anterior half of the acetabulum. Most of the sac is occupied by the voluminous vesicula seminalis which forms a few short curves. The prostatic region is inconspicuous.

The ovary is  $\cdot 05\text{--}\cdot 07$  mm. in diameter and lies on one side of the median line at approximately mid-length of the body. The receptaculum seminis is immediately behind, and slightly inwardly from, the ovary, so that its position is approximately median. Laurer's canal lies above it and the shell gland which is somewhat obliquely placed. The short uterus forms a few loops and contains very few eggs. The latter measure  $\cdot 08\text{--}\cdot 09$  by  $\cdot 06\text{--}\cdot 065$ . Vitellaria extend from the posterior end of the worm almost to the mid-acetabular level, and encroach very little on the testicular field though they occupy most of the post-testicular region. The large yolk reservoir lies adjacent to the front edge of the anterior testis.

### *Stictodora diplacantha* n. sp.

(Fig. 6-8)

Many specimens of this small Heterophyid were obtained from cormorants, *Phalacrocorax varius*, from Port Gawler, South Australia. Length,  $\cdot 8\text{--}1\cdot 14$  mm.; maximum breadth,  $\cdot 21\text{--}\cdot 29$  mm.; the usual dimensions being  $\cdot 99\text{--}1\cdot 05$  by  $\cdot 21\text{--}\cdot 4$  mm. The longest worms are relatively the narrowest. Extreme anterior end narrowed; posterior broadly rounded. The breadth is fairly constant in the anterior two-thirds of the body, being about  $\cdot 17$  mm., widening from the level of the genital atrium to reach the maximum in the region of the ovary and testes. In some specimens there may be a constriction in the prepharyngeal region, and also a slight waist in front of the atrium. The body is beset with delicate sharp spines, these being especially abundant as far back as the level of the posterior testis in some cases, of the ovary in others, while in others they do not reach the region of the pharynx. The rest of the body bears extremely minute spines, the surface being almost smooth.

The oral sucker is ventral, subterminal,  $\cdot 061\text{--}\cdot 065$  mm. long and  $\cdot 538$  mm. wide. The prepharynx is relatively long,  $\cdot 145\text{--}\cdot 153$  mm. in length; pharynx  $\cdot 044\text{--}\cdot 046$  mm. long by  $\cdot 029\text{--}\cdot 031$  wide; and the oesophagus  $\cdot 047\text{--}\cdot 086$  mm. in length. The crura extend almost to the end of the worm and lie close to the lateral border of the body in the post-atrial region. The distance from the crural bifurcation to the head end of the worm is  $1\cdot 3\text{--}3\cdot 2$  of the body length.

The genital atrium, together with the highly modified acetabulum, is a conspicuous structure in cleared specimens. It is often slightly oblique; its measurements are, length  $\cdot 065\text{--}\cdot 067$  mm., breadth  $\cdot 092\text{--}\cdot 1$  mm. Its front edge is distant from the head end  $1\cdot 1\text{--}1\cdot 7$  of the total body length, so that the whole organ lies at the end of the middle third of the body. The acetabular portion contains two well-defined gonotyls, not quite equal in size, one of them (that on the ovarian side of the worm) being more ventrally placed than the other. These gonotyls

are similar in structure, each having about 18 strongly curved, sharply-pointed hooks arranged in two series—a basal row of 12-15 (13-14) smaller hooks and a group of five or six much larger central hooks, 17-21  $\mu$  long. The specific name is based on the double gonotyl with its prominent armature. The actual atrium has, when at rest, strongly folded walls and into it open the sex ducts. The genital pore is not quite median, being displaced away from the ovarian side of the worm.

The testes are similar, .077-.09 mm. in diameter, with an entire margin, and situated in the intercaecal region in the posterior third of the body. The anterior testis is at about the same level as the ovary, but on the opposite side. The posterior testis lies behind the ovary but is more medially situated. The thin-walled vesicula seminalis is constricted into three spherical structures, each about .05-.08 mm. in diameter. The most posterior lies more or less median between the ovary and the testes and is below the receptaculum seminis; the other two are situated between it and the atrium. The third portion lies adjacent to, or immediately above, the short thick-walled prostate region of the male duct, which is .048 mm. long by .03 mm. wide and is succeeded by the narrow male canal, about .04 mm. long by .012 mm. wide. The latter enters the posterior or postero-lateral region of the atrium.

The ovary is approximately spherical, .05-.12 mm. in diameter, situated on one side of the median line, and distant from the head end 1:1.4 of the body length, i.e., it lies in the posterior third of the worm. The oviduct arises from its inner surface. The receptaculum seminis is relatively large, its diameter (.07-.1 mm.) at times exceeding that of the ovary. It partly overlies the latter and may also extend above part of the posterior testis and even reach the edge of the other testis. Below it is part of the vesicula seminalis. The uterus occupies most of the available space in the region behind the atrium and underlies the crural region (in part), testes, receptaculum, vesicula and even part of the ovary. Its terminal portion is more or less transversely placed in front of the gonads, becoming very narrow as it passes forwards just below the male duct to enter the atrium. The scattered vitelline follicles occupy a very thin zone dorsally and ventrally in the post-testicular region and reach almost to the end of the worm. The two main ducts travel forwards and inwards, one of them lying close behind the posterior testis, the two ducts joining to form the small yolk reservoir, about midway between the two testes and situated behind the receptaculum. The common yolk duct travels forwards to terminate below the latter. Eggs are very numerous, .032-.033 by .015-.017 mm. in size, with a slight narrowing towards the opercular end, and sometimes a minute projection marks the edge of the operculum.

A slide containing the type and several paratypes has been deposited in the South Australian Museum. The species resembles *Stictodora japonica* Yamaguti (1939, 175) more closely than any other yet described, but differs from the Japanese parasite in body proportions, relative lengths of the oesophagus and prepharynx, relative position of the testes, structure of the acetabular region and the position of the latter in relation to the body length. Ciurea (1933, 108) placed the genus in the Galactosominae.

#### AUSTRALIAN HOSTS AND PARASITES RECORDED IN THIS PAPER

##### ANHINGA NOVAE-HOLLANDIAE Gould

*Clinostomum australiense* S. J. Johnston, Burnett River, Qld.

##### PHALACROCORAX CARBO NOVAE-HOLLANDIAE Stephens

*Paryphostomum radiatum* (Rud.), Burnett River, Qld.; Bathurst, N.S.W.;

Tailem Bend and Hope Valley, S. Aust.

*Echinoparyphium phalacrocoracis* Yamaguti, Tailem Bend, S. Aust.

*Petasiger exaeretis* Dietz, Bathurst, N.S.W.; Tailem Bend, S. Aust.

*Hysteromorpha triloba* (Rud.), Bathurst, N.S.W.; Tailem Bend, S. Aust.



## PHALACROCORAX MELANOLEUCUS Vieillot

*Paryphostomum radiatum* (Rud.), Brisbane and Longreach, Qld.; Tuggerah, N.S.W.; Gippsland, Vict.; Taillem Bend, S. Aust.; Perth, W. Aust.

*Echinoparyphium phalacrocoracis* Yam., Taillem Bend, S. Aust.

*Petasiger exacretus* Dietz, Tuggerah, N.S.W.; Taillem Bend, S. Aust.

*Hysteromorpha triloba* (Rud.), Glenelg River, Vict.; Taillem Bend, S. Aust.

*Dolichosacculus solecarius* (S. J. Johnston), Tuggerah, N.S.W. ..

PHALACROCORAX SULCIROSTRIS Brandt (syn. *P. ater* Lesson)

*Paryphostomum radiatum* (Rud.), Burnett River, Qld.; Glenelg River, Vict.; Taillem Bend, Adelaide, S. Aust.; Perth, W. Aust.

*Echinoparyphium phalacrocoracis* Yam., Taillem Bend, S. Aust.

*Petasiger exacretus* Dietz, Taillem Bend, S. Aust.

*Hysteromorpha triloba* (Rud.), Taillem Bend, S. Aust.; Perth, W. Aust.

## PHALACROCORAX VARIUS Gmel.

*Stictodora diplacantha* n. sp., Port Gawler, S. Aust.

PHALACROCORAX FUSCESCENS Vieillot (syn. *P. gouldi* Salv.)

*Paryphostomum radiatum* (Rud.), Taillem Bend, S. Aust.

*Hysteromorpha triloba* (Rud.), Taillem Bend, S. Aust.

## MELEAGRIS GALLOPAGO Linn. (Turkey)

*Echinoparyphium recurvatum* (Linst.), Melbourne, Vict.

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# **A NEW MELOMYS FROM QUEENSLAND WITH NOTICE OF TWO OTHER QUEENSLAND RATS**

By H. H. FINLAYSON

## **Summary**

Of the three rats from central coastal Queensland dealt with herein, two belong to species which, though known, have not been figured. An opportunity is taken, therefore, of making good that deficiency so far as the material permits and of amplifying the description of one of them. The third proves to be an undescribed form which may be known as

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[Read 8 October 1942]

PLATES VIII AND IX

Of the three rats from central coastal Queensland dealt with herein, two belong to species which, though known, have not been figured. An opportunity is taken, therefore, of making good that deficiency so far as the material permits and of amplifying the description of one of them. The third proves to be an undescribed form which may be known as

***Melomys callopes* sp. nov.**

A small species with very long tail and ear. Nearest to Lonnberg's *littoralis* located 500 miles further north, but differing in its more sombre trizonal colour; in a greyish-white instead of buffy belly; in a more complex pelage with multi-banded fur; and in the larger skull with longer anterior palatine foramina.

The following description is based upon a single specimen, originally in alcohol; an adult female taken about 30 miles south-west of Duaringa in the Rockhampton district. The animal was pregnant with two early embryos in the right horn of the uterus only; stomach contents—granular multi-coloured vegetable matter without identifiable fragments.

*External Characters.*

Form moderate, limbs rather stout. Head broad with a comparatively short blunt muzzle; well developed though sloping upper lip and prominent mentum. Mystacial vibrissae profuse but attenuated; the longest 43 mm.; black with the extreme tip white. Eye small. Ear large and broad; its substance white at the base of conch and most of the pinna dark lead colour.

*Manus* large and stout; length from base of carpal pad to tip of apical pad 11 mm.; breadth at base of digits 2-5, 5 mm.; length of third digit, 4.5 mm.; lower side of digits naked and strongly ridged, claws short reaching but slightly beyond apical pads in a palmar view. Pads large and prominent; carpals subequal; the outer descending below the inner but beginning at a lower level proximally; first and second interdigitals broadly pyriform; third bell-shaped and with a distinct postero-external satellite. Outer carpal = inner carpal > first interdigital > third > second.

*Pes* very broad interdigitally, but tapering rapidly and evenly to the heel where there is considerable lateral infringement of hair; length, 25 mm.; breadth at base of digits 1-5, 6 mm.; third digit, 6 mm. Digits and sole quite naked; former well grooved, claws projecting well beyond apical pads. Plantar pads very large, high, and prominent; beautifully sculptured with unusually broad and crisp outlines. Inner metatarsal much elongated, 4.5 mm., but nearly straight and its surface weakly striate transversely. Outer metatarsal small, round. First interdigital large reniform and with a small semi-detached satellite postero-externally; second and third pyriform and subequal; fourth reniform with its posterior extremity tapered and a distinct postero-external satellite. Inner metatarsal > first interdigital = fourth > second = third > outer metatarsal.

Tail long, very slender and nearly nude with the scales everywhere prominent; mid-dorsally there are 15 scales per centimeter and three hairs per scale.

Mammæ prominent; posterior 4 mm. from base of clitoris; anterior 6.5 mm. from posterior.

### *Pelage*

From a skin made up from alcohol after a few weeks' immersion only and with the colouration apparently unchanged, short, fine and moderately soft; dense and difficult to part. Mid-dorsal length of the main pile ca. 8 mm, with a sparse overlay of a longer pile reaching 11 mm. The main pile is not homogeneous but consists of two types of hairs; type one, which are stouter, are blackish plumbeous for the basal quarter of the shaft, followed by a band of Ridgway's clay colour, topped by an attenuated blackish tip; type two, which are more slender and slightly longer, are blackish plumbeous for their basal three-quarters, followed by a greyish-white (Tillicul Buff) terminal band which is carried above the clay zone of the first type and mingles with the blackish points of the latter. The sequence of colour zones from the base up is therefore plumbeous, clay, blackish, greyish-white and again blackish, the latter being contributed by the tips of type one and by the blackish "guard" hairs, which, however, are scarcely coarser than the former and which are white-tipped on the rump.

The resulting external mid-dorsal colour viewed at a little distance is a sombre greyish-brown, near Ridgway's Mummy Brown, with a slight ashy grizzling. On the shoulders and rump the colour is colder (about Mouse Grey), the belt of warmer colour separating these areas, extending as a distinct saddle-shaped marking down to the edges of the belly.

Sides clearer and more buffy, forming at the junction with the belly a sharply contrasted lateral band of Ochraceous Buff extending from the angle of jaw to femoral area.

Ventrum basally, a paler grey than on the dorsum, externally nearly white, but the basal grey everywhere emergent except for a large gular and smaller inguinal area which are creamy white to base. Head like the midback. Upper lip whitish; cheeks buffy like the transition areas of the sides. Ears internally nearly nude with a sprinkling of brownish hairs; externally well haired and almost black with a sprinkling of silver-grey on the posterior margin; the ear as a whole much darker than and well contrasted with the head and back. Limbs externally like the sides, internally grey-white like the belly; dorsum of carpus and manus sparsely haired white, an indistinct greyish marking extending down the outer margin of the metacarpus; dorsum of pes white, faintly tinged with grey and without markings.

Integument of tail about Fuscous of Ridgway above, paler beneath; hairs blackish-brown above and darker than scales; below greyish-brown and paler than the scales. The tail as a whole is darker above than below, but is not strongly bicolor.

### *Skull*

General form broad and stout, but not with dense ossification. Muzzle region short, broad and deep. Nasals tapering strongly but evenly to the frontals, their lateral margins straight or nearly so; the naso-frontal suture narrow but not pointed and with emargination in midline. Anterior root of zygoma thrown boldly outwards almost at a right angle to the long axis of the skull; general zygomatic outline squarish but with the angles softened; the anterior zygomatic width almost equal to the posterior. Anteorbital fossa feebly developed. Interorbital region broad and with smoothly rounded edges. Lacrymals small. Braincase large, moderately elongated in shape, smooth and unridged, with a long interparietal suture. Interparietal long, narrow, spanning the braincase. In side view the skull is unusually deep from above downwards throughout its length, especially in the muzzle region. Free edge of zygomatic plate nearly vertical;

slightly convex at upper end, very slightly concave at lower. Anterior palatine foramina longer than in other species of similar size, reaching beyond the anterior margin of  $M^1$ . Posterior margin of palate with a well-developed spur. Mesopterygoid fossa very wide anteriorly. Parapterygoid fossa deep and with well-defined boundaries. Bullae small.

Incisors and incisive angle moderate; molar rows parallel; the molar crowns simple without supplementary cingular cusps and with the laminae normally arched and discrete. Lower molars with distinct supplementary posterior cusps. Coronoid process of mandible reduced.

*Flesh dimensions* (in alcohol)—Head and body, 120; tail, 144; pes, 25; ear, 18.

*Skull Dimensions*—Greatest length, 31.5; basal length, 26.6; zygomatic breadth, 15.5; braincase breadth, 14.4; interorbital breadth, 4.7; nasals length, 11.0; nasals greatest breadth, 3.7; palatal length, 16.8; palatilar length, 14.4; ant. pal. foramina length, 6.1, *ibid* breadth, 2.1; bullae, 4.7; upper molar series, 6.0; molar wear moderate on all laminae.

*Type and Habitat* as given above.

Structural figures of the nine Australian species of *Melomys* previously described are lacking<sup>(1)</sup>, and existing descriptions alone are frequently inadequate for a proper conception of relationship. Although the present form is closest to *littoralis*, it clearly cannot be merged with that species as described. It may be noted that the habitat, 80 miles from the sea and in an area of comparatively dry and temperate climate, is less coastal than that of the small, more northerly, tropical forms. As the type is in good preservation, an extended description and figures of manus, pes, skull and molars are provided.

#### PSEUDOMYS (LEGGADINA) PATRIUS Thomas and Dollman 1908

A specimen of this comparatively rare form is available from Cooti Uti, about 100 miles north of Rockhampton, where it was collected on the sea coast by Mr. R. Vallis. The locality is about midway between that of the type and the southerly record near Gladstone given by Troughton in 1936.

In dimensions and all structural characters which can be tested it is in good agreement with the type, but the colouration of the skin made up from alcohol is richer—the dorsum being near Ridgway's Hazel and therefore much brighter than the pale Wood Brown of the original description. How much of this difference is due to alteration in the alcohol it is now impossible to say, but it is noteworthy that the collector spoke of it when taken as a "red-sided mouse." The distribution of colour on appendages and body is exactly as in type.

The specimen was, unfortunately, not sexed before skinning and was too shrunk for an accurate account of its plastic parts to be drawn up. The skull, however, adult with worn molars, is nearly perfect and gives the following dimensions: greatest length, 22.8; zygomatic breadth, 11.4; braincase breadth, 11.1; interorbital breadth, 3.5; nasals greatest length, 8.2; ditto greatest breadth, 2.1; palatal length, 12.0; palatilar length, 10.6; ant. pal. foramina length, 4.3; ditto breadth, 1.5; bulla, 4.0; upper molar series, 4.1.

In dorsal aspect it is very close to the skulls of *hermannsburgensis*, falling between the two phases figured by me (Trans. Roy. Soc. S. Aust., 65, pl. xi, fig. A-B (1941)), but differs in the nasals which are longer and narrower and taper more rapidly. In palatal aspect, too, the mesopterygoid fossa is wider and more open throughout its length and the bullae are smaller in all dimensions. In the dentition the incisors are broader from side to side though of equal depth and

<sup>(1)</sup> Excellent figures of three extra Australian species have recently been published by Tate: Bull. American Mus. Nat. Hist., 72, 594 (1936).

angle. The molar row is longer and all its members heavier than in the Central animal. The anterior cingular cusp on  $M^1$  is small but distinct and is more apical than in any *hermannburgensis* skull reviewed (*loc. cit.*).

*RATTUS CULMORUM* cf. *CULMORUM* Thomas 1908

A well preserved example of this rat is in hand from the same locality as the *Melomys* species described above. It is an adult male with worn molars and is in moderately close agreement (in the characters conventionally defined) with the typical race as given by Thomas, though in one or two items it shows an approach to the New South Wales race *vallesius*. The above-mentioned locality is 300 miles south of that of the typical race and about 600 miles north of that of *vallesius*.

*External Characters*

Stout, short-limbed, medium-tailed. Head large and heavy; both deep and wide and with a short muzzle. Mystacial vibrissae well developed, to 45 mm., the shorter members black with white tip, but the longest entirely white. Eye medium. Ears comparatively short and broad; the conch and central pinna nearly white in substance; margins and upper pinna pigmented to a pale slate only; hairing medium.

*Manus*—Weak and narrow; length from base of lower carpal to apical pad of mid digit, 11.5 mm.; breadth at base of digits 2-5, 4.5 mm.; middle digit, 4.5 mm. Palm and digits quite nude and pale yellowish-white throughout; nails of medium length, stout and blunt; well fringed. Pads small but well raised and with sharp outlines. Carpals much larger than interdigitals; the outer rather larger, both in length and area, than the inner but the disproportion slight; base of the inner carpal profusely haired from the carpus. Interdigitals subequal in area, one and three bell-shaped or irregularly oval, two broadly oval; three with a small semi-detached satellite at its postero-external corner. Outer carpal > inner carpal > first interdigital = second = third.

*Pes*—Length, 27 mm.; breadth at base of digits, 1-5, 6 mm.; third digit, 5.5 mm. Sole and digits pale like manus; under-surface of toes and sole nude; the former moderately grooved and the latter very smooth; nails well developed, and moderately fringed. Pads small and weak, except the inner metatarsal which is long (4 mm.), straight and narrow, club-shaped and tapering posteriorly; outer metatarsal very small, oval and barely 1 mm. posterior to the fourth interdigital; first interdigital roughly inverted bell shape and with a large low level heel of similar shape postero-external to it; second interdigital pyriform; third very different from second, broader, almost triangular or heart-shaped; fourth bell-shaped and larger than the first and with a smaller, more distinct heel. In area inner metatarsal > second interdigital = third = fourth > first > outer metatarsal.

Tail shorter than head and body (88%) and rather slender; pale in substance and with the scales showing strongly on all surfaces; mid-dorsally 10 scales per cm.; hairing sparse; pale brown above, lighter below, but not strongly bicolor. Testes large and scrotal; scrotum pigmented on posterior lobes only.

*Pelage*

Apparently longer (15 mm. mid-dorsally) and perhaps denser and softer than in the typical race, but the colouration quite as given by Thomas.

*Flesh Dimensions* (in alcohol)

Head and body, 147; tail, 123; pes, 27; ear, 18; rhinarium to eye, 18; eye to ear, 13.

*The Skull*

Greatest length, 36.0; basal length, 33; zygomatic breadth, 20.1; braincase breadth, 15.9; interorbital breadth, 5.0; nasals length, 12.9; nasals breadth, 3.5;

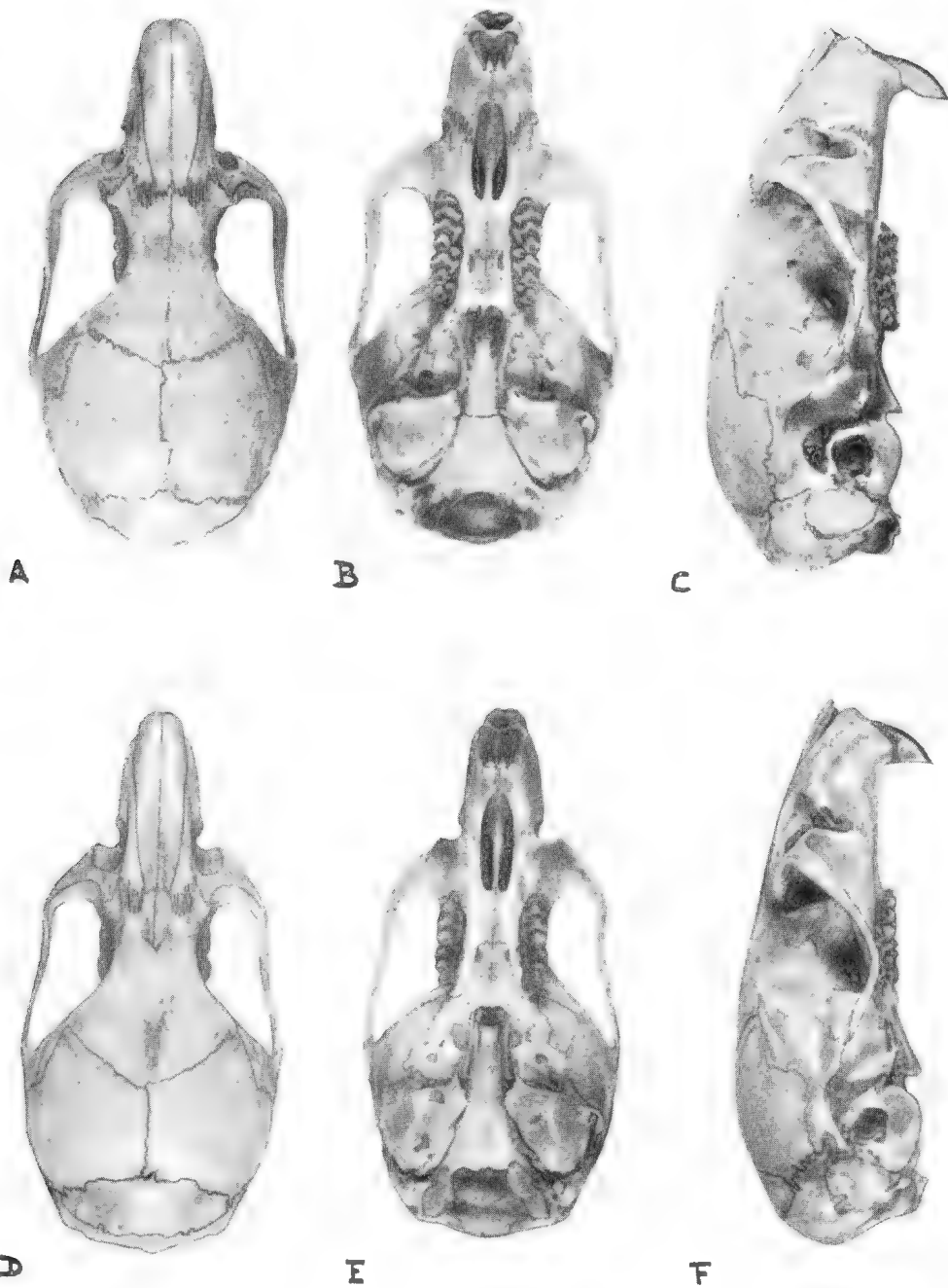


Photo by H. H. Finlayson



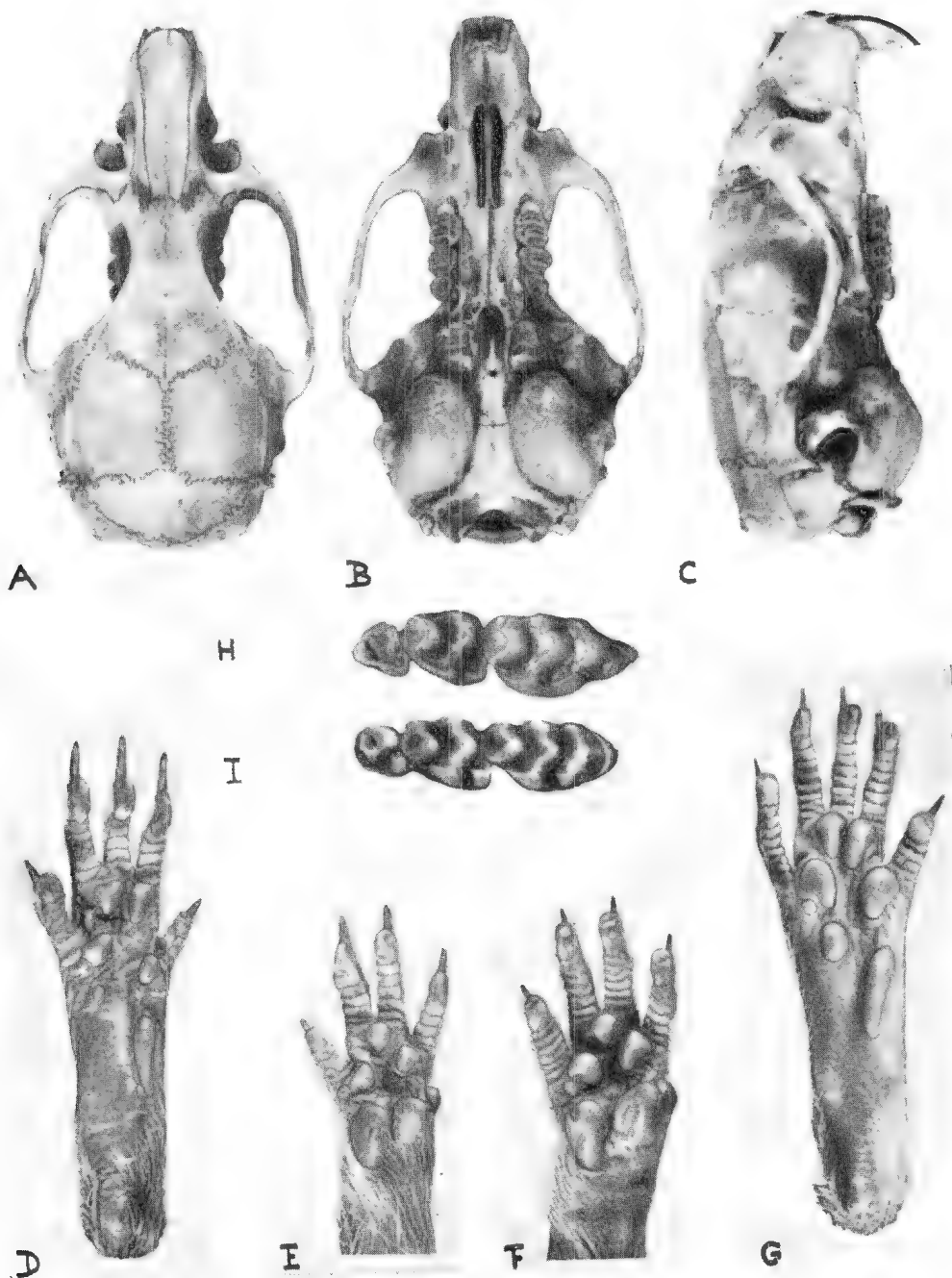


Photo by H. H. Finlayson

palatal length, 19.5; ant. pal. foramina length 7.6; ditto breadth, 2.1; bulla, 8.8; upper molar series (crowns), 7.0.

Impressed by the striking agreements, both structural and metrical, existing between the above *culmorum* skull and that of the animal obtained by the Horn Expedition in Central Australia, described by Waite as *Rattus greyi* and later re-named *Rattus tunneyi dispar* by Brazenor, I have been led to re-examine two of the skulls upon which Waite based his account. These show appreciable discrepancies with his figure which tend to obscure the likeness to *culmorum*. In particular, the heading of the temporal ridges in their posterior course is much exaggerated, the interorbital region is too wide and the bullae much too globular. The molars, however, represent accurately the condition in the younger of the two skulls (spec. B) and indicate a complete absence of the several supplementary cusps described for the typical *tunneyi* by Thomas; they are also absent from Brazenor's figures of *dispar*. Waite's molar dimension is evidently taken from the root at alveolar level, which considerably exceeds the crown measurement.

Careful re-measurement of the two skulls, specimen B a sub-adult male with unworn molars, and the much older female from Tennant's Creek obtained after the Horn Expedition, gives the following values respectively:

Greatest length 34.2, 37 ca.; basal length 30.6, —; zygomatic breadth (posterior) 19.0, 20.5; braincase breadth 15.0, 15.9; palatal length 18.5, 19.7; ant. palatine foramina  $7.9 \times 1.7$ ,  $7.7 \times 2.1$ ; bullae 7.8, —; upper molar row 6.5, 6.6.

I am unable to check external characters with material, but Waite's dimensions (which exceed Brazenor's type considerably) show no great disparity with *culmorum* varieties, and the pelage characters of the presence of spines and white-based belly fur appear to be the only remaining distinction from that group of rats.

On the whole, there seems as much propriety in treating *dispar* as a race of *culmorum* as of *tunneyi*, and the point is not without interest in its bearing on the derivation of the Central fauna.

The assistance of three correspondents, Mrs. Charles Barnard, Mr. A. Dettrick and Mr. R. Vallis, in forwarding specimens is gratefully acknowledged.

## EXPLANATION OF PLATES

### PLATE VIII

- A, B, C: Dorsal, palatal, and lateral views of skull of adult ♀ of **Melomys callopes** sp. nov. from Duaringa district, Queensland. (x 2.2 ca.)  
 D, E, F: Dorsal, palatal, and lateral views of skull of an adult unsexed example of *Pseudomys (Leggadina) patrius* Thomas and Dollman from Cooti Uti, 100 miles north of Rockhampton, Queensland. (x 3.2 ca.)

### PLATE IX

- A, B, C: Dorsal, palatal and lateral views of skull of an adult ♂ of *Rattus culmorum* cf. *culmorum* Thomas from Duaringa district, Queensland. (x 1.9 ca.)  
 D, E: Right pes and manus of same. (x 2.5 and 3.0 respectively.)  
 F, G: Right pes and manus of **Melomys callopes** sp. nov. (x 2.8 and 3.3 ca. respectively.)  
 H: Right upper molars of *Pseudomys (Leggadina) patrius* Thomas and Dollman. (x 9 ca.)  
 I: Right upper molars of **Melomys callopes** sp. nov. (x 5.6 ca.)

# **ADDITIONS TO THE FLORA OF SOUTH AUSTRALIA NO. 41**

By J. M. BLACK, A.L.S.

## **Summary**

The following species are described in English in the revised Part 1 of the author's "Flora of South Australia."

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No. 41

By J. M. BLACK, A.L.S.

[Presented 8 October 1942]

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## GRAMINEAE

**Poa humifusa**, nov. sp. Glabra, perennis, longe stolonifera; folia conferta; laminae setaceae, flaccidae, saepe curvatae, 2-8 cm. longae, vaginis arctis multo longiores; ligula ovata, brevissima, glabra; crista foliorum cum caule capillari longiore ex quoque nodo stolonum gracilius orta; panícula parva terminalis, 1-1½ cm. longa, ramis duobus brevibus, utrisque 1-3 spiculas gerentibus; spiculae 3-4 florum, 3-4 mm. longae; prima gluma 2 mm. longa, subtrinervis, secunda 2½ mm. longa, 3-nervis; glumae florum obtusae, fere 3 mm. longae, 5-nerves, demum divergentes, dorso et nervis exterioribus lanatae; palea carinis ciliata, glumae florum aequilonga.

Scrub at Keith and near Mount Gambier, Nov. 1917, *J. M. B.*

**Poa halmaturina**, nov. sp. Perennis, parva, rigida, glabra, rhizomate repente; folia pleraque in cristibus basilaribus; laminae filiformes, fere pungentes, curvatae, 2-3 cm. longae, vaginis laxiusculis longiores; ligula minuta, truncata; caules erecti, filiformes, 5-10 cm. longi; panícula spiciformis, 1-3 cm. longa, ramis 1-3, erectis, alternis, 1-3-spiculatis; spiculae subsessiles, 2-3-florum, 4-5 mm. longae; glumae florum subacutae, 3½ mm. longae, 5-nerves, parte inferiore et basi lanatae; palea aequilonga, nervis ciliata.

Rocky River, Kangaroo Island, "In burnt consolidated dunes," Dec. 1940, *J. B. Cleland* (on Tate Society Expedition).

## LILIACEAE

**Lomandra densiflora**, nov. sp. Folia rigida, canaliculata vel planiuscula, 20-40 cm. longa, 1½-6 mm. lata, vaginis in capillamenta brunnea fissis; flores masculi patentes, plerique singuli sed in ramis erectis paniculae brevissimae (3-4 cm. longae) dense conglomerati; paniculae rhachis ramique angulares, omnino laeves; caulis perbrevis, latiusculus, plus minusve planus, quasi inter vaginas obtectus; perianthium tenue, segmentis liberis patentibus, exterioribus lineari-lanceolatis, acuminatis, subhyalinis, 3 mm. longis, segmentis interioribus fere ovatis, 2½ mm. longis, viridibus; antherae albae; ovarii rudimentum adest; bractea linearis hyalina, pedicellum circa 1 mm. longum aequans; flores feminei singuli sed approximati, patentes vel nutantes, in paniculam angustam 2-3 cm. longam dispositi, pedicello 2-4 mm. longo, cum bractea lineari hyalina duplo longiore; perianthium campanulatum, basi umbilicatum, 4 mm. longum, segmentis erectis, acutis, subrigidis, apice patentibus; capsula fere matura ovoidea, 6 mm. longa.

Mount Lofty Range and southern districts. Spring and summer. *J. B. Cleland and others.*

**Lomandra fibrata**, nov. sp. Folia filiformia, debilia, 20-50 cm. longa, ½-1 mm. lata, minute scabra, vaginis in capillamenta numerosa fissis; flores masculi erecti, subsessiles vel brevissime pedicellati, in paniculam spiciformem, paucifloram, 2-3 cm. longam dispositi, ramis basilaribus brevibus unifloris; rhachis

laevis; caulis inter vaginas obtectus; bractea linearis hyalina florem subaequans; perianthium 3-3½ mm. longum, viride, segmentis liberis, exterioribus acuminatis apice incurvis, interioribus paulo brevioribus, ovatis, flavis; flores feminei subsessiles, erecti, campanulati; spica pauciflora, 2-2½ cm. longa, interdum cum paucis ramis basilaribus 1-2 floris; perianthium femineum 3-4 mm. longum, segmentis omnibus acutis; capsula matura nondum visa.

Mount Lofty Range; Mount Remarkable. Nov. *J. B. Cleland*.

Near *L. sororia*, F. v. M., but the latter has a longer, more branched panicle and the outer segments of the flower are shorter than the inner and without the long tips of *L. fibrata*.

Both these species have (like *L. caespitosa* Benth., Ewart) very short spikes, racemes or panicles, sometimes almost concealed among the dense erect bases of the leaves. The long very slender leaves of *L. fibrata*, distinctly scabrous to the touch although the marginal hairs are minute, are characteristic of that species. The thin crowded flowers, spreading horizontally, in the male panicle of *L. densiflora*, and the angular rhachis and rather broad flattish stem below the panicle, distinguish that species from its associates.

#### POLYGONACEAE

In October 1941 the Pink Dock (*Rumex roseus*, L.) was found to have established itself near Blinman, in the Flinders Range, during the previous two or three years. In September 1942 it was reported to have extended its range and to be occupying a considerable area. Like those other adventives, Salvation Jane (*Echium plantagineum*) and Soursob (*Oxalis cernua*), it is a handsome feature in the landscape, but it has the additional advantage of being nutritious. Experience has shown that sheep like the succulent foliage, and the residents regard it as a useful immigrant. Pink Dock has been cultivated, to a moderate extent, in gardens near Adelaide, where its ripe fruits have a handsome aspect in mass.

## AUSTRALIAN ACANTHOCEPHALA NO. 3

By T. HARVEY JOHNSTON and EFFIE W. BEST, University of Adelaide

### Summary

The present paper deals with species of *Corynosoma* obtained from bird and mammalian hosts from South Australian waters. Types of the new species, as well as representatives of the others referred to in this report, have been deposited in the South Australian Museum. We desire to acknowledge our indebtedness to the Director of the latter institution for material from *Delphinus delphis*; and also to the Commonwealth Research Grant to the University of Adelaide for financial assistance.

## AUSTRALIAN ACANTHOCEPHALA

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[Presented 8 October 1942]

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PHALACROCORAX VARIUS Gmelin—*Corynosoma clavatum* Goss.

DELPHINUS DELPHIS Linn.—*Corynosoma cetaceum* n. sp.

TURSIOPS TRUNCATUS Montague—*Corynosoma cetaceum* n. sp.

NEOPHOCA CINEREA (Péron), syn. *Arctocephalus forsteri* of Johnston 1937—*Corynosoma australe* Johnston.

GYPSOPHOCA DORIFERA (Wood Jones)—*Corynosoma clavatum* Goss.

***Corynosoma cetaceum* n. sp.**

(Fig. 1-10, 13)

The material examined came from two collections from dolphins—*Delphinus delphis* (type host) from St. Vincent Gulf, and *Tursiops truncatus* from Port Lincoln. The parasites from the former host were rather larger and much more numerous than those from the latter but the arrangement of the body spines and proboscis hooks was similar, as also was the general anatomy. The copulatory bursa was fully everted in most of the males from *Delphinus*.

The length ranged from 3 to 7 mm. in males (exclusive of the bursa), and 1.7 to 3 mm. in females, the greater number of specimens approaching the upper limit of the range in both sexes. The comparative shortness and stoutness of the female allowed ready differentiation of the sexes. The anterior disc-like region varied from 1.3 to 1.7 mm. in diameter in males, and from 1.3 to 2 mm. in females, and is covered with conspicuous spines, .05 mm. long, surrounded by very obvious protuberances of the cuticle. Similar spines extend towards the posterior end of the body in both sexes, but they do not surround the genital aperture.

The proboscis and its hook arrangement closely resemble those of *C. antarcticum*, except that the former tapers evenly from the base to its tip (fig. 1, 3). In a typical specimen the organ measures .97 mm. long, .33 mm. wide at the base, and .17 mm. at the tip. There is a short neck, .2 mm. in length, .45 mm. in width, and devoid of spines. The portion of the body immediately following the neck sometimes projects from the disc as a cone, which like the disc, bears spines. The proboscis hooks are arranged in 18 longitudinal rows of 14-16 hooks, whose form in profile is shown in fig. 3.

The proboscis sheath is double-walled and measures 1.3 by .3 mm., the ganglion lying at about its midlength. The body cavity, particularly in the disc is, as usual in the genus, crossed by very numerous strands of muscle within which the small irregular leaf-like lemnisci are enclosed. The lacunae of the body wall are very inconspicuous, and longitudinal vessels are hardly to be distinguished from the general network.

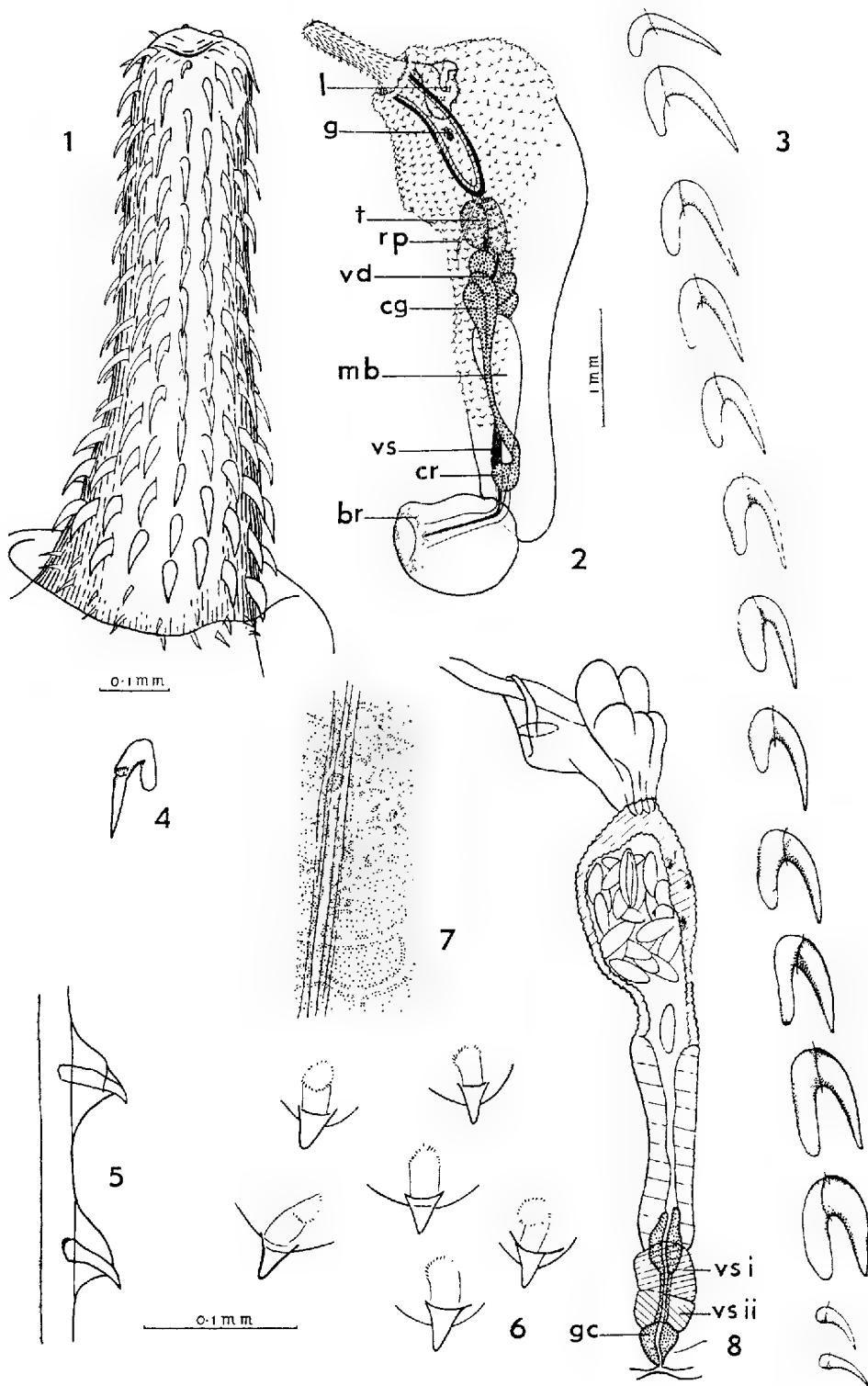


Fig. 1-8. *Corynosoma cetaceum*: 1, proboscis; 2, male; 3, proboscis hooks in profile; 4, malformed hook often seen in any position along the rows; 5-6, body spines; 7, lacunar system; 8, female system. Fig. 3-6 are drawn to the same magnification.

ab, auricle of bursa; b, bursa; br, bursal ray; cg, cement gland; cr, cement reservoir; g, gland; gc, gland cell; gl, genital ligament; l, lemniscus; mb, markbeutel; r, retinaculum; rp, retractor of proboscis; t, testis; vd, vas deferens; vs, vesicula seminalis; vs 1, vs 2, vaginal sphincters.



*Male*—The testes lie side by side, almost at the same level, just behind the proboscis sheath. The vasa deferentia unite at about the anterior end of the "markbeutel," the common duct being swollen at its base to form a thin-walled vesicula seminalis. The ducts of the six compact cement glands unite, three on each side, to form lateral ducts which are swollen at their bases and join to form the U-shaped cement reservoir. The everted bursa is particularly large and robust, approximately 1 mm. in length and in breadth, with eighteen sensory rays. The posterior fifth of the body is completely devoid of spines.

*Female*—The uterus proper is about 1 mm. long and .25 mm. in maximum width. The uterine bell is borne at an angle to it and is .5 mm. long, with very marked projections bearing the lateral apertures. The anterior half of the uterus is thin-walled and swollen, and is succeeded by a narrower muscular portion. Both vaginal sphincters are well developed. The eggs are thick-shelled, with obvious polar prolongations of the inner shell. Those within the swollen portion of the uterus appeared to be all about the same size, .13 by .045 mm. The ventral body spines reach the level of, but do not actually surround, the genital aperture.

The generic concept of *Corynosoma* Lühe 1904 has been so modified that Van Cleave (1936) has stated that "spines around the genital orifice, at least in the males, is the only single criterion available for recognising the genus." Nevertheless, the species here described combines so many of the features of the original concept that the lack of spines around the sex aperture cannot exclude it from *Corynosoma*. It would seem that the peculiar expanded and flattened form of the lemnisci may assume importance as a diagnostic feature. The strong musculature of the disc obscures their form in whole mounts, and they can be seen clearly often only on dissection; consequently, the term band-like which is sometimes applied to them is probably a misinterpretation, based on a side view.

The species differs from the closely allied *C. antarcticum* from Antarctic seals in several respects. The body spines of the latter, as seen in specimens available for comparison, are much less conspicuous, and though of approximately similar size, are more deeply embedded in the subcuticula and extend in both sexes to surround the genital aperture. There are also differences in the detailed anatomy and proportions of both male and female organs. The presence of eighteen longitudinal rows of proboscis hooks occurs commonly in the genus. The forms of the proboscis and the arrangement of its hooks resemble those of both *C. antarcticum* and *C. australe*, but the latter is a much smaller parasite. The posterior ends of males of the three species are illustrated in fig. 11-13 for comparison. The arrangement of the spines surrounding the genital opening is quite distinctive.

*Corynosoma* sp. has been recorded from *Delphinus longirostris* from Japanese waters by Yamaguti (1935), but the size and proportions are different from those of *C. cetaceum*, being 14 mm. in length and 1 mm. in width of the disc in the former, as against 3 mm. by 2 mm. in the Australian species. The material described from *Delphinus delphis* is that recorded by us as *Corynosoma* sp. (Johnston and Deland, 1929).

#### CORYNOSOMA CLAVATUM Goss

(Fig. 14-19)

The species was described by Miss Goss (1940) from material collected from three species of cormorants from Western Australia. We have a single male specimen from *Phalacrocorax varius* from Port Gawler. It is not in a very satisfactory condition for comparison, but the host relationship, size, and form of the proboscis and its hooks have led us to identify it as *C. clavatum*.

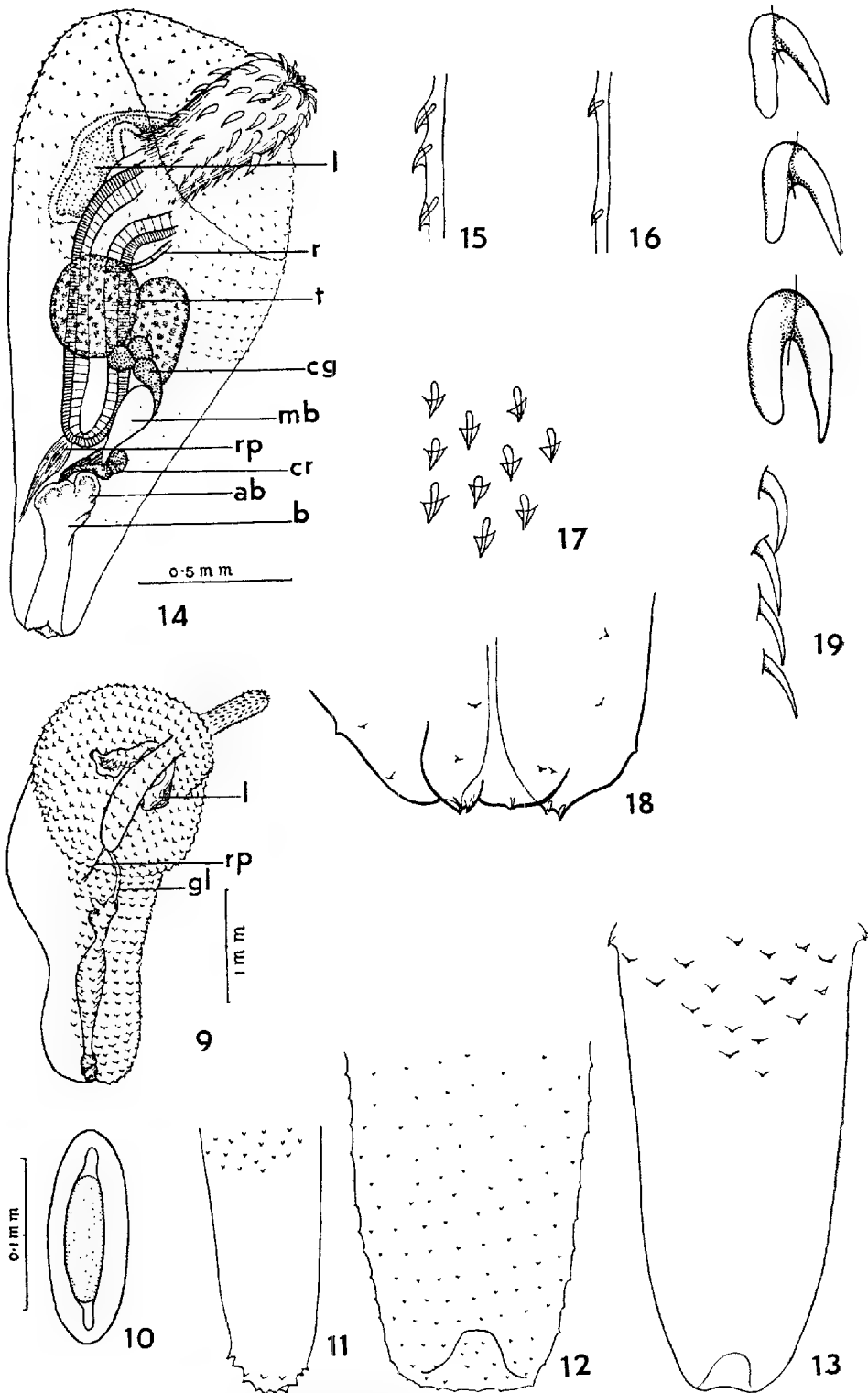


Fig. 9, 10, 13, *Corynosoma cctaceum*: 9, female; 10, egg; 13, posterior end of male. Fig. 11, *C. australe*, posterior end of male. Fig. 12, *C. antarcticum*, from Weddell seal. Fig. 14-19, *C. clavatum*, from seal: 14, male; 15, spines from disc; 16, ventral body spines; 17, disc spines; 18, posterior end of male; 19, hooks in profile. Fig. 10, 15-19 are drawn to the same magnification. Lettering as in preceding figures.

Three males, regarded as belonging to the same species, were collected from a seal, *Gypsophoca dorifera*, which had been captured off Yorke Peninsula and had died after having been some time in captivity. The only important respect in which the specimens differ from the account given by Miss Goss, is in the presence of distinct spines about the genital aperture. The sizes of the various organs, except the cement glands, are comparable. The small size of the cement glands in our material may indicate immaturity. Miss Goss referred to the parasite (1940, 1) as *Polymorphus clavatus*, as well as *C. clavatum*. Figures showing the distribution of the body spines, as well as certain anatomical features, exhibited by material from the seal, are now given, and in addition, details of the hooks and spines (fig. 14-19), since these are not shown in the original account. *C. phalacrocoracis* Yamaguti (1939, 337) from *Phalacrocorax pelagicus* from Japan is a very much larger form.

#### CORYNOSOMA AUSTRALE Johnston

(Fig. 11)

This species was described from the South Australian hair seal which was incorrectly identified as *Arctocephalus forsteri*. The latter name is now restricted to a species occurring in New Zealand, our local seal being known as *Neophoca cinerea*, under which name the parasite should be listed. Re-examination of the material from Pearson Island has revealed some errors in the original account. The scale beside fig. 8 is marked to indicate 2 mm., but should be 1 mm., the testes are recorded as .04 mm. instead of 0.4 mm., and the lemnisci have been ascertained, on dissection, to possess the irregular leaf-like form common in the genus.

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# **A SECOND SPECIMEN OF WYULDA SQUAMICAUDATA ALEXANDER**

By H. H. FINLAYSON

## **Summary**

To the courtesy of the Rev. J. R. B. Love, formerly of Kunmunya Mission in the Kimberley Division of Western Australia. I owe a field skin and skull of this interesting marsupial, which apparently has not been taken since the description of the single type specimen by Alexander in 1918.

## A SECOND SPECIMEN OF WYULDA SQUAMICAUDATA ALEXANDER

By H. H. FINLAYSON

[Presented 10 October 1942]

## PLATES X AND XI

To the courtesy of the Rev. J. R. B. Love, formerly of Kunmunya Mission in the Kimberley Division of Western Australia, I owe a field skin and skull of this interesting marsupial, which apparently has not been taken since the description of the single type specimen by Alexander in 1918.

The locality is about 150 miles north-west of that of the type and upon the opposite coast of the peninsula. Mr. Love reports that the Worora blacks call it Ilanguarra, and state that it lives amongst rocks and occurs throughout all their country as far as Obagooma, near Derby, 250 miles south-west of the Mission.

Mr. Alexander (1) justly remarks at the close of his careful description and summary that the generic or subgeneric arrangement of *Wyulda* and its allies, *Phalanger* and *Trichosurus* stands in need of review with more adequate material. This desideratum may be long delayed but the time seems opportune to re-examine the former animal as far as may be, with the aid of this new example.

In general a close agreement with the types has been found, but there are some discrepancies, and needful additions and amplifications have been made, with a review of its phylogenetic position. In the following description, from motives of convenience and brevity, direct comparisons are usually made with *Trichosurus*, but without prejudice of affinity.

*External Characters*

These cannot, of course, be checked with accuracy from the filled skin. The approximate dimensions are: head and body, 427 mm.; tail, 330; pes, 49; ear, 28. The ear measurement would probably be at least 25% greater in the flesh—approximately 35 mm. The ratio of head and body length to tail length is about as in *T. vulpecula*, and in many species of *Phalanger* as well.

In life the superficial aspect of the animal would probably justify the use of the vernacular *Cus Cus* already applied to it by Longman (3). Head short and wide, with the muzzle region rather weaker than in *Trichosurus* but less conical and pointed than in *Phalanger*. All facial vibrissae are strongly developed and entirely black; the mystacial reach 73 mm., the genals 62 and the supraorbitals 57 mm. Rhinarium large, naked and its surface finely granular; it has a well marked median groove with a small projecting process at its base as in *Trichosurus*.

Limbs noticeably shorter than in *Trichosurus*; vibrissae well developed on forelimb; ulna carpal and anconeal white; medial antebrachial black; they are more conspicuous than in *Trichosurus* owing to the shorter coat. The calcaneal set also present and white.

The manus is shrunk but seems small for the size of the animal. Digital formula  $4 > 3 > 5 > 2 > 1$ , as given for the type. This, while agreeing with the condition quoted for *Phalanger*, is not unknown in *Trichosurus*, where, however,  $4 > 3 > 2 > 5 > 1$  is more usual. The claws are short, not strongly curved, nearly obscured by the fringing hairs of the digits, and (in the dried state) scarcely projecting beyond the apical pads. In the flesh their saliency would be still further reduced and their piercing and prehensile effectiveness much inferior to that of either *Trichosurus* or *Phalanger*. The apical and palmar pads are in relative development and shape quite similar to *Trichosurus*, but the surface, particularly of the latter elements, is marked by transverse parallel or concentric striae, more continuous and less granular than in that genus, but quite similar to the condition to be seen in dried skins of *Phalanger maculatus* and *P. breviceps*.

In the *pes* the general condition seems very close to *Trichosurus*; the pads about as well developed and with similar shapes, though evidence of special affinity to either *Phalanger* or *Trichosurus* can scarcely be looked for here, since Bensley (2) has shown that the condition overlaps in the two genera. In the dried condition, however, the pads in *Wyulda* are more conspicuous than in the latter owing to their finer striation. The claws are relatively longer and sharper than on the manus.

Tail as in the original description, but the basal portion is densely furred like the back (not scantily, as stated), and the transition to the tubercular portion is abrupt and linear. The tubercles increase in size and prominence towards the middle reaches of its length and then fall away distally again, though they are everywhere very distinct. Their arrangement is such that they fall into well-marked linear series, crossing the tail surface obliquely at an angle of  $40^\circ$  to its midline. Measured along the dorsal midline their frequency increases from four to six per cm. The interscalar spaces are beset with black bristle hairs, averaging three per scale and about one-half of a scale in length, and visible only on close inspection. On the distal half of the ventral surface of the tail, the chief site of the prehensile function is free from tubercles and transversely creased, a condition present in both *Trichosurus* and at least some *Phalanger* species also.

In the material of *Phalanger* available to me there is little in the caudal scalation of the dorsal surface to recall that of *Wyulda*, but on the ventral surface of some examples of *P. maculatus* just proximad of the prehensile area, low but distinct and very separate tubercles are developed in transverse rows of five, separated by the width of two—a condition which might be regarded as an incipient phase of that of *Wyulda*. Alexander suggests that the nudity of the tail is a primitive character, and quotes in support the individual variation in the scale development in some species of *Phalanger*. This is difficult to disprove, but it seems more probable that the loss of hair is a recent change made in response to a newly acquired habit of rock climbing. There is some slight support for this in the analogous case of *Pseudochirus dahli*, and still more in the specialised condition of the scales which differ widely in their roughened, tubercular and protuberant character, from those of *Hypsiprymnodon* the only primitive marsupial with which direct comparison is possible.

#### *Pelage*

Very short, fine, soft and copious. Constitution of pelage, vertical distribution of colour and general appearance of coat quite like some of the northern and central forms of *T. vulpecula*; the fur duller and without the sparkle and gloss of the southern animal, or of most species of *Phalanger*. Mid-dorsally the main pile reaches 12 mm. with a sparse overlay reaching 16 mm. Here the basal half of the fur is Pale Neutral Grey, the succeeding quarter a pale slightly vinaceous brown near Wood Brown, the subterminal band ashy—near Tilleul Buff—and the extreme tips and guard hairs black. Towards the rump the basal colour becomes warmer and more ochraceous and the brown zone tends to merge with the base.

The general dorsal colour is a pale ashy grey finely grizzled and obscurely mottled on the nape, shoulders and rump with washes of buff. The head and mid-back are coldest in tone and are near Neutral Grey. The buffy areas are inconspicuous and bear no relation to the strong rufosity of fore-quarters common in similarly aged males of *T. vulpecula*. The overlay of black is slight except mid-dorsally where an obscure stripe is developed. Sides like the back, but somewhat paler and less grizzled, though still mottled irregularly with buff. Ventral fur creamy white to base except on throat and chest, where it is Pallid Neutral Grey; external colour creamy white mottled with pale buff. Scrotum nearly nude. Head pure cold grey like the midback, muzzle upper lip and orbital ring weakly washed with brown, but not strongly contrasted as in *Trichosurus* and without the dark chin patch. Ears nearly nude internally, externally rich brown (Bistre) at base,

elsewhere very sparsely clad with greyish-white; the bases strongly contrasted with the head. Limbs externally like sides, internally like belly, but with a slightly warmer tone, especially on the hind limbs where the basal colour is pale ochraceous buff. Manus and pes uniform greyish-brown, near Pale Drab, and not strongly contrasted with the limb.

From the original illustration (*loc. cit.*) the present specimen differs in the much paler and colder dorsal colour, whiter ventral colour and inferior lateral demarcation except posteriorly towards the hind limb, where it is abrupt; from Cayley's, fig. 1, pl. x, in Troughton's "Furred Animals of Australia" (1941) it differs in lacking the strong reddening of head and limbs.

### Skull

This gives the following dimensions in mm. (those of the type follow them in brackets): basal length 74.1, (73); greatest breadth 51.4, (54); nasals length 31.2 (29); nasals greatest breadth 14.4, (14.5); nasals least breadth 7.3 (10.3); constriction breadth 9.6,<sup>(1)</sup> (8.7); palate length 43 ca., (33); palate breadth outside M<sup>2</sup> 23.5, (23); palate breadth inside M<sup>2</sup> 14.2, (15.2); anterior palatine foramina 5.5, (5.5); basicranial axis 25.3, (24.5); basifacial axis 48.4, (48.5); facial index 191, (198); horizontal length of P<sup>4</sup> 5.0,<sup>(2)</sup> (4.7); length M<sup>1-3</sup> 12.1, (12.5); length of lower I, 13.9, (12.0).

Important discrepancies are shown only in the least breadth of nasals, and palate length; and in both cases the type description seems erroneous as the illustrations do not support them, but give measurements agreeing closely with my own.

In general dorsal outline and many structural features the skull is close to *Trichosurus*; under the first head the chief differences lie in the relatively greater posterior width, and the attendant change in shape of the zygomatic arch, the posterior width of which is markedly superior to the anterior or middle width. This is an accentuation of a condition already present in *Trichosurus*, whereas in *Phalanger* anterior and posterior width are usually equal or the anterior even greater.

Other respects in which resemblance is shown to the former rather than the latter genus are as follows:

- (1) The muzzle region generally is even narrower and more slender than in *Trichosurus*; the nasals project beyond the naso-maxillary suture and overlap the gnathion; the premaxillae make a larger contribution to the wall of the nares than the maxillae.
- (2) Greater development of the post-orbital process of the jugal.
- (3) Detailed condition of the braincase and its rugosities and the lambdoid and sagittal crests.
- (4) The upper profile, which ascends steadily and evenly from the nasion to a vertex in the sagittal crest just anterior to the auditory meatus and without bulging in the frontal region.
- (5) The condition of the squamous temporal which is inflated both in its dorsal and occipital aspects, to a degree unequalled in the recent Phalangeridae. In relation to *Trichosurus* it presents no novel features, however, except that of degree—the three species *T. caninus*, *T. vulpecula* and *Wyulda* forming a progression in this, while in *Phalanger* it is markedly less.
- (6) At the base of the skull the auditory bulla presents features of interest. Its degree of expansion is intermediate between that of *T. vulpecula* and *T. caninus*, and therefore much greater than in *Phalanger* where the parts are scarcely raised. The bulla shows a tendency towards the more primitive bilobed condition found in *Petaurus* and *Drumicia*, being

<sup>(1)</sup> On supraorbital edges; below them, 7.5.

<sup>(2)</sup> Maximum diameter along oblique axis, 5.6.

divided by a shallow oblique sulcus into two moieties. But whereas in these genera both moieties are contributed by the alisphenoid, in *Wyulda* only the postero-internal element is so derived while the antero-external portion, which is the more prominent of the two, is formed from a ventral process of the squamosal descending from the floor of the glenoid fossa. This arrangement seems to be unique in the Phalangeridae, though it is fore-shadowed in a small percentage of skulls of *T. vulpecula*.

In the original description of the type, the bullae were stated to be very large and responsible for the great posterior width of the skull; this, however, is only true if the mastoid process of the periotic is regarded as part of the bulla, and for this there seems no justification at all. Anteriorly the mastoid is well separated from the alisphenoid-squamosal bulla as defined above, and posteriorly its contours blend completely and without demarcation with the general occipital cellular inflation.

Some other points in which it shows differences of a minor kind from either *Trichosurus* or both genera, concern the hard palate which anteriorly is less rugose than in either and the interorbital concavity which favours *P. orientalis* in shape.

Finally, the expansion of the mastoid process of the periotic is responsible for another peculiarity of the skull—namely, the great reduction in the paraoccipital process of the exoccipitals. In the caudal view these prongs are pressed against the mastoids and squamosals almost throughout their entire length, and scarcely project as free elements at all; in the two allied genera they project prominently.

#### Mandible

Likeness to *Phalanger*, especially to the smaller species, is more readily traceable here than in the skull. The area of the ascending portion of the ramus with respect to the body is less than in *Trichosurus*, the condyle is set lower, the coronoid process rises higher and its anterior margin slopes back at a greater angle, and the symphysis is slightly shorter. The general condition of the masseteric fossa and of the condyle itself is much as in *Trichosurus*, but the inflected angle differs from both the related genera, in being less acute at the extremity and its medial margin is not recurved ventrally to form a flange; the floor of the pterygoid fossa differs correspondingly.

#### Dentition

*Incisors*—The upper incisors in the present example differ considerably from those of the type, the differences being partly due perhaps to the greater wear of the former.  $I^1$  which was stated by Alexander to be nearly cylindrical has here an antero-posterior width at the alveolar margin nearly twice its transverse width, and much of its disproportion as compared with  $I^2$  would seem to be due to the relatively much greater wear on the latter.  $I^3$  in this example could never have reached two-thirds the size of  $I^1$  at any stage of wear, though it is to be noted that in the tabular summary of characters of the type it is said to be "moderate," as in *Trichosurus*; in the latter it averages nearer one-third of  $I^1$ .

In general, when compared with similarly worn examples of *T. vulpecula*, the agreements are much more notable than the differences. This is particularly so in the upright setting of the incisors in the premaxillae and the loss of all tendency to procumbency, and in the close proximation of the first incisors to one another in the midline. The first lower incisors are relatively slightly longer than in *Trichosurus*, narrower and less spatulate and they ascend towards their occlusion with their upper opponents, at a slightly steeper angle; sympathetically the incisor-premolar diastema is shortened. Two lower vestigial incisors are present as in the type; the anterior procumbent, the other upright.

The incisors as a whole therefore, especially in the lower jaw, are slightly more primitive than in *Trichosurus*, but show very little special resemblance to *Phalanger*.

The canine, in size and situation, is exactly as in *Trichosurus*, but is slightly sharper and more strongly curved.



*Premolars*—Upper  $P^1$  about one-half of the size of the canine and similar in size, shape and position to *T. vulpecula*, in its usual condition, though there is some variation in the latter. Median upper premolar quite absent. The upper  $P^1$  is a remarkably large tooth, exceeding any of the molars in sectional area and greatly exceeding them in bulk. It exhibits strong sectorial specializations, actually exceeding in some respects those of *Trichosurus*, but in detailed morphology is intermediate between that genus and the more advanced forms of *Phalanger*, cf. *lululae* and *rothschildi*, as described. The crown of the tooth, both cone and blade, projects far below the crown surface of the molars. The outer surface of the blade is concave, a shallow but well-defined sub-triangular fossette occupying the greater part of its area, while the upper portion is marked by three prominent narrow vertical grooves, extending to the cutting edge which is correspondingly serrate; and vestiges of a parallel series are to be seen upon the antero-internal face. Almost the whole area of the latter is occupied by an occlusal facet of greater extent and more even development than in *Trichosurus*. The tooth is rotated outward to a marked degree, probably more strongly than in any other recent marsupial, and its cutting edge makes an angle of about  $45^\circ$  with the long axis of the molar series; a line drawn along its cutting edge, if produced, bisects the crown of  $M^4$ . The lower  $P_4$  also larger than any of the lower molars, and similarly rotated, grooved and worn. As in the type a vestigial premolar is pressed against the base of  $P^4$ .

*Molars* generally very close to those of *Trichosurus*. In sectional area the sequence in the upper series is  $M^1 = M^2 > M^3 > M^4$ , and in the lower  $M_2 = M_3 > M_1 > M_4$ ; both formulae agreeing with *Trichosurus* except that in *T. caninus*  $M^4$  may be equal to  $M^1$ . The declension in size of the posterior molars, both above and below, is steeper in *Wyulda* than in *Trichosurus*, and much steeper than in the species of *Phalanger* to which I have access, in which there is a marked tendency towards the enlargement of the third and fourth molars both above and below, leading to subequality of the upper molars, and in the lower jaw even to such formulae as  $M_4 > M_3 > M_2 > M_1$ .

The molars are slightly broader in relation to their antero-posterior length than in *T. vulpecula* and their over-all shape is rather less quadrate, the width of the posterior of  $M^2$  and  $M^3$  being about one-third less than that of the anterior; in both respects they approach *T. caninus* more closely than *T. vulpecula*. The molar enamel is smooth and free from the pitting and marginal crenulation frequent in *Phalanger*. The lingual cusps are slightly less elaborated than in *Trichosurus* but in all structural detail of significance, such as the longitudinal linking of the lingual cusps, development of anterior and posterior terminal ledges, transverse ridging of the buccal cusps, exaggeration of the paracone on  $M^1$  and the wearing pattern, there is a very close agreement with that genus.

The dentition as a whole, therefore, resembles *Trichosurus* more closely than *Phalanger*. Traces of more primitive conditions linger in the lower incisors and canine, but the complex of characters which marks the progressive herbivorous evolution of the subfamily, and in which the former is held to be more advanced are either equally developed in *Wyulda*, or in some respects carried still further.

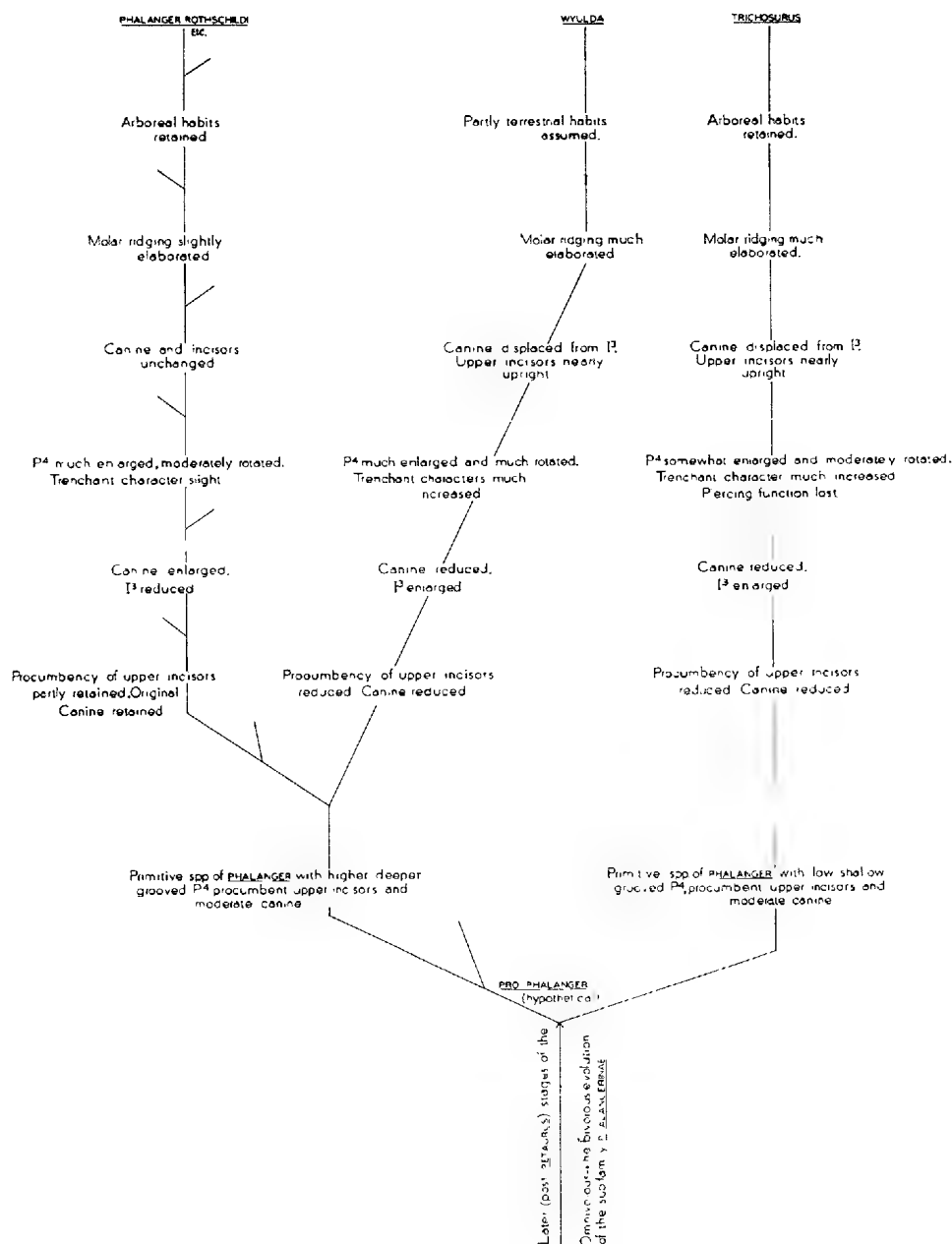
#### *Relationships*

Setting aside a considerable substratum of characters in which an intermediate conditions is shown, the status of *Wyulda* in the matters here reviewed may be roughly summarised in the following categories:

- 1 Resemblances to *Trichosurus*:
  - (a) general structure of skull; (b) general level of dentition; (c) pelage.
- 2 Resemblances to *Phalanger*:
  - (a) digital formula; (b) striation of pads; (c) tail (in origin); (d) mandible (in part); (e) lower incisors, canine and  $P^4$  (in part).

3 Characters in which *Wyulda* is peculiar or shows an extreme development of a condition already present in either *Phalanger* or *Trichosurus*:

- (a) reduction of forelimb and manus; (b) loss of piercing specialisations in the claws of manus; (c) tail (in detail); (d) bulla (in detail); (e) inflation of temporals; (f) paraoccipital processes; (g) axial rotation and wear of  $P^4$ ; (h) molar gradation; (i) condition of mandibular angle; (j) petrophile habit.



The somewhat heterogeneous character of *Phalanger*, containing as it does several incipient specialisations more or less divergent, creates a taxonomic problem which Alexander in his discussion (*op. cit.*) opines may best be solved by the recognition of subgenera therein. In suggesting the inclusion of *Trichosurus*

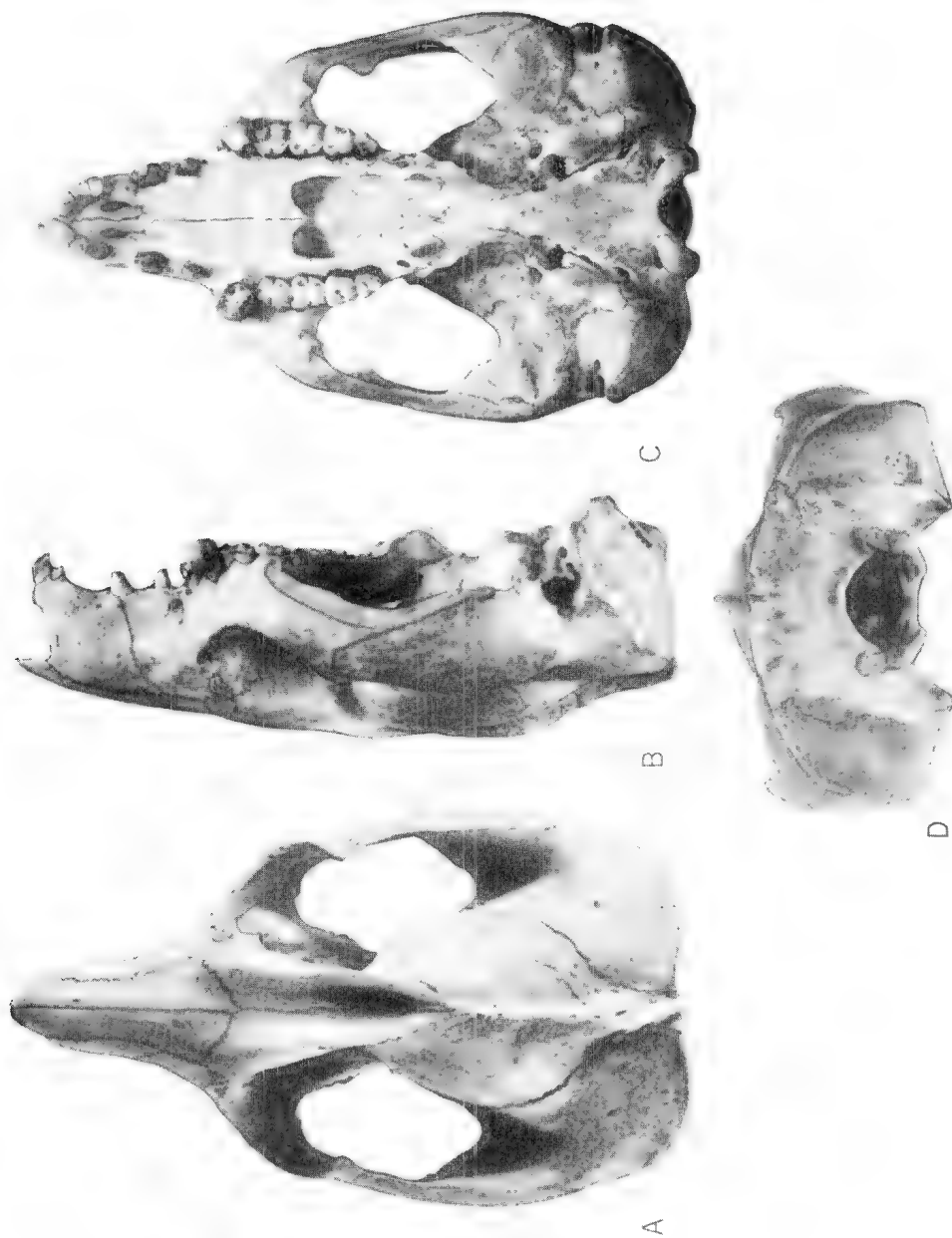


Photo by H. H. Finlayson

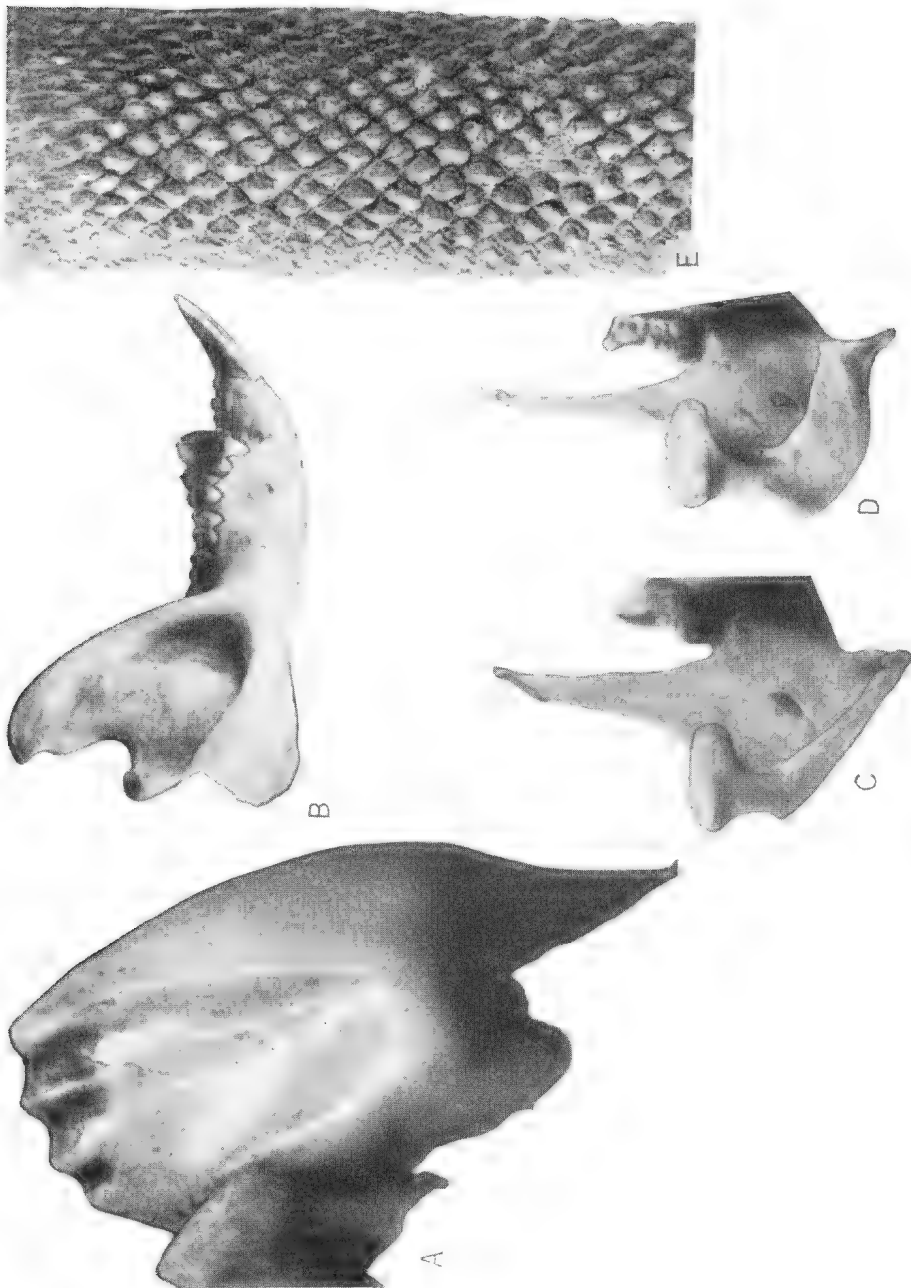


Photo by H. H. Finlayson

in this scheme of subgenera, however, he has evidently overlooked the fact established by Bensley with ample material for comparison that the *Trichosurus* dentition as compared with that of any of the numerous forms of *Phalanger* represents a distinct advance in the herbivorous specialisation which is the major theme in the evolution of the subfamily.

In the same way, it would not appear from the results of the present detailed examination, that *Wyulda* (despite some basic resemblances especially in plastic characters) differs very widely from any of the species of *Phalanger*, and that even the most conservative view could scarcely withhold generic rank from a species presenting such a complex of differential characters as is listed at (3) above.

The resemblances to *Trichosurus* are striking, but any derivation of *Wyulda* from that genus, either by retrogression or further evolution, is clearly ruled out by the evidence of the posterior premolars. This leaves as the obvious alternative an independent collateral development of both from ancestral forms of *Phalanger* which differed in premolar character in somewhat the same way as the Bettongiinae do from the Macropodinae.

On this view the evolution of the three genera, as interpreted by dentition alone, might be represented somewhat as in the scheme on page 260.

The dental evolution of *Phalanger* and *Trichosurus* is closely associated with an arboreal habit in all the species of both, and is phytophagous rather than herbivorous in the wider terrestrial sense. Since the dentition of *Wyulda* is on much the same phytophagous level as *Trichosurus*, it would appear that the present partly terrestrial rock haunting habits of the former represent a recent development, initiated possibly by the desiccation of the habitat, and that the response to this has so far only affected the plastic anatomy of the forelimb and manus and possibly the tail.

Regarding the caudal depilation, Mr. Love informs me (*in litt.*) that the Worora have views of their own. It came to pass in this way. Long ago, in the early time, Ilangurra had a bushy tail like Burkumba the ordinary opossum. One day when Ilangurra was beginning to climb into a tree, a passing echidna, Koonunginya, in mischievous mood, siezed him by the tail and tried to pull him down. He did not succeed but instead pulled all the hair out of the tail. Thereupon Ilangurra jumped down and in a rage seized Koonunginya and threw him into a prickly bush. Since that day of discord Ilangurra has had a bare and scaly tail and Koonunginya has been covered with spines.

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#### EXPLANATION OF PLATES X AND XI

##### PLATE X

Fig. A, B, C, D—Dorsal, lateral, palatal and occipital aspects of the skull of *Wyulda squamicaudata* Alexander, adult ♂ from Kunmunya. (x1 ca.)

##### PLATE XI

Fig. A—Upper posterior premolar of the left side of *Wyulda squamicaudata* Alexander. Adult ♂ from Kunmunya; a postero-external view of the blade at about 90° to the cutting edge, with the paracone of M<sup>1</sup> in situ. (x11 ca.) Fig. B—Lateral view of mandible. (x1.1 ca.) Fig. C—Posterior view of same to show condition of the inflected angle and pterygoid fossa. (x1.8 ca.) Fig. D—Ditto in *Trichosurus vulpecula*. (x1.4 ca.) Fig. E—Proximal portion of dorsal surface of the tail of *Wyulda squamicaudata* Alexander. (x2 ca.)

# **THE STRUCTURAL CHARACTER OF THE FLINDERS RANGES**

By D. MAWSON

## **Summary**

### **EXPLANATORY NOTES RELATING TO THE ACCOMPANYING MAP**

The map herewith submitted, illustrating the distribution of the rock formations of the central portion of the Flinders Ranges, details only the broader features of this interesting area. It is not presented as a final and accurate representation, but as an approximation to illustrate the points to be made regarding the structure and stratigraphy of the region. It also serves the purpose of coordinating several geological cross-sections of portions of the area already published by the author, and it illustrates their relation to the structure as a whole. The geographical position of each of these lines of section is clearly indicated.

## THE STRUCTURAL CHARACTER OF THE FLINDERS RANGES

By D. MAWSON

[Presented 8 October 1942]

## EXPLANATORY NOTES RELATING TO THE ACCOMPANYING MAP

The map herewith submitted, illustrating the distribution of the rock formations of the central portion of the Flinders Ranges, details only the broader features of this interesting area. It is not presented as a final and accurate representation, but as an approximation to illustrate the points to be made regarding the structure and stratigraphy of the region. It also serves the purpose of co-ordinating several geological cross-sections of portions of the area already published by the author, and it illustrates their relation to the structure as a whole. The geographical position of each of these lines of section is clearly indicated.

This map is based on the pastoral plan issued by the Government Department of Lands and Survey. But as the latter is mainly of the nature of a sketch plan, the general detail, apart from the location of the trig. stations, which are accurately placed, is only very roughly delineated. In critical areas, therefore, some slight corrections have been introduced in the compilation of the present map.

In the region between Nildottie Gap, Angorigina Hill and First Hill the data available are so meagre and contradictory that the exact location of the Wirrealpa track and the trend of streams in that area is still in doubt. Consequently, it has been left more or less featureless.

In dealing with the area north of Blinman, data from Howchin's account (1922) interpreted in the light of knowledge of the sedimentary succession in our recent work has been incorporated.

The heights quoted are mean aneroid readings, except in the case of St. Mary's Peak, the highest point in South Australia, and the railway sidings which have been fixed with precision, respectively by the Survey Department and by the S.A. Railways engineers.

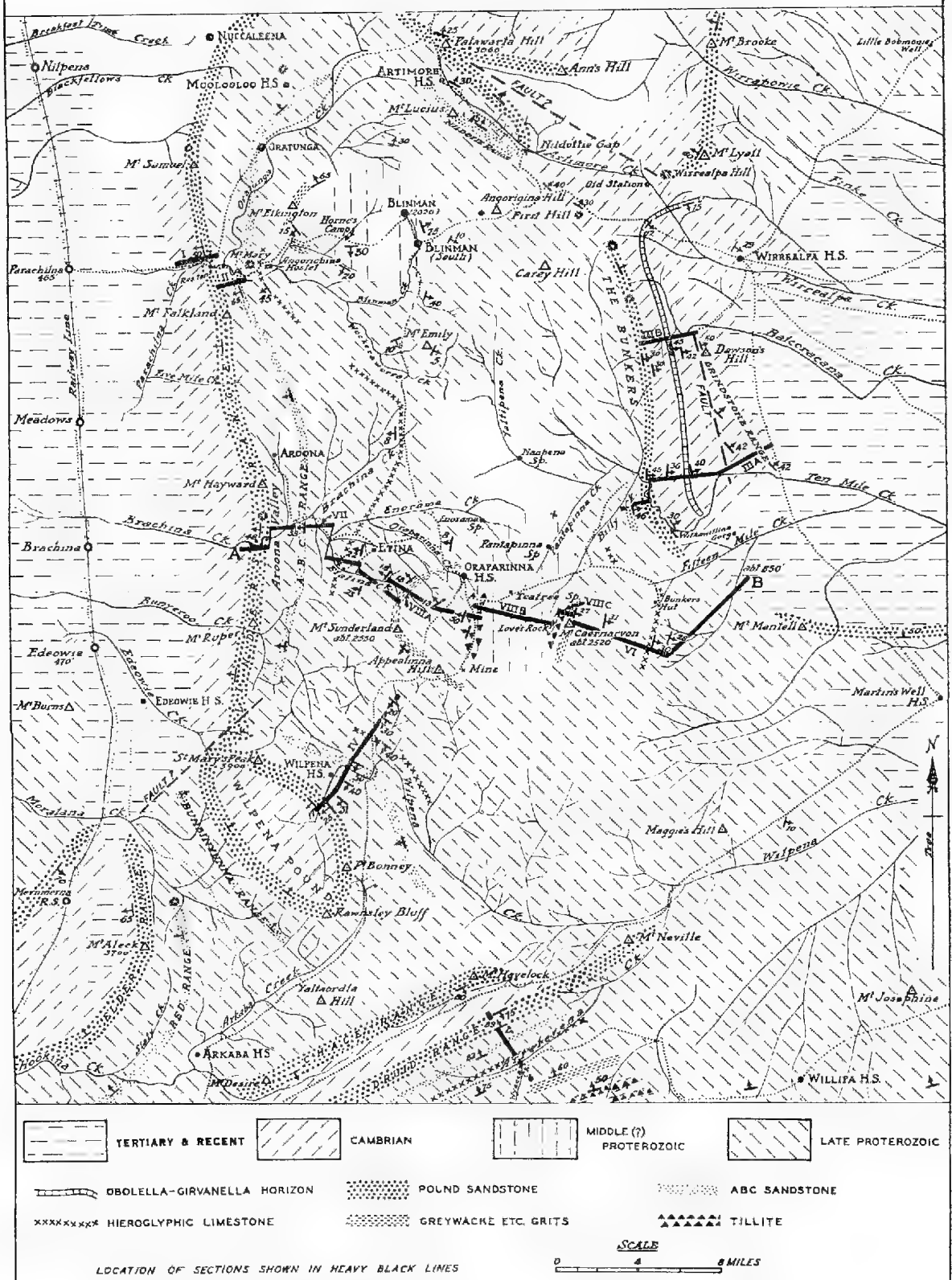
No attempt has been made to indicate minor faulting, and only certain major faults that have come under observation are recorded. There are also major north to south faults on either side of the elevated block which constitutes the body of the ranges. The lines of these faults are hidden beneath Pleistocene to Recent deposits and have not been fixed exactly, and consequently, are not shown in the plan.

It has been established that there are large blocks in this area which are little affected by major faulting, though in other localities the interpretation of the true succession of the beds is greatly complicated by fault dislocations. My own method has been to select for careful measurement a number of blocks which have been found to be least affected by faulting and then to compare the result obtained, thereby the better detecting omissions or duplications in the record and, at the same time, supplying data for ultimately discussing variations in the nature of sedimentation in different portions of the area.

The dips and strikes recorded are, for the most part, mean figures for the neighbourhoods indicated.

The rocks of the area have been divided into four periods, indicated on the map by appropriate hatching. Where there is no hatching on the map, knowledge of the locality is yet too meagre to venture a suggestion with any reasonable degree of confidence as to the character of the rock formation.

# THE CENTRAL AREA OF THE FLINDERS RANGES





Areas which are known to be or believed to be occupied by the Pound Sandstone are specially indicated and have not been included in the hatching scheme indicating age. This decision has been adopted since, though the author regards the Pound Sandstone as, in all probability, Cambrian in age, there are others who prefer to regard it as the last deposition of the Pre-Cambrian.

The fossiliferous Cambrian formation which everywhere overlies it is very rich in fossil Archaeocyathidae; in fact, this is the most famous locality in the world for that group of fossils. At a considerable higher level there is a notable fossiliferous horizon rich in *Obolella* and *Girvanella*. The location of this band is indicated in the case of the Wirrealpa Cambrian Basin. So far it has not been identified elsewhere within the area of this present map, though we have found it represented in the Cambrian basin to the west of Copley.

The basin area of Wilpena Pound is hatched to indicate the Cambrian terrain, but it has not yet been fully explored and so far no fossiliferous Cambrian strata have been proved to exist there. It may be that all the limestone which formerly must have existed there has been removed by denudation. In any case, I hold the Pound Sandstone to be of Cambrian age at least in its upper section.

The thick unfossiliferous sandstones of the Grindstone Range, separated from the fossiliferous Cambrian beds by a line of disturbance and faulting have been indicated as Cambrian, though it is possible that this is a down-faulted block of Ordovician age.

Locations of several of the marker beds in the late Proterozoic succession are indicated in the map. These, however, are locations where these formations have been met with, and it is not implied that they do not exist in other areas; in fact, it is certain that they do, but such areas have not been examined in sufficient detail to fix the position of these horizons.

The core areas in the neighbourhood of Oraparinna and Blinman are only very roughly delineated, for in fact, up to the present, they have not been subjected to critical examination.

The low unrelieved plains on either side of the Ranges are paved with outwash material, much of which is in the nature of coarse boulder beds. Where these have been dissected by later streams they are observed to be of considerable thickness; vertical faces of over 50 feet have been noted. In regions of greatest accumulation these beds must be very much thicker than this. Such beds outcropping at the surface are in the main undoubtedly Pleistocene to Recent in age. But occasionally remnants of older horizontally disposed sandstones and pebble beds composing isolated buttes are met with: these may conceivably be outliers of the Eyrian formation of early Tertiary age. An example of such is the block lying immediately to the south-east of the township of Copley. On the map, all such Tertiary to Recent sediments are grouped together without distinction.

## GEOLOGICAL SECTION ACROSS THE FLINDERS RANGES

During the past few years, when dealing with the sedimentary succession of the older rocks of the Flinders Ranges, I have submitted for publication in the Transaction of the Royal Society of South Australia, a number of geological sections across the strike of the beds in certain selected areas. The exact location of each of those lines of section is now indicated on the map supplied (p. 263) herewith. Thus I and II refer to the geographical location of the sections illustrated on page 256 of vol. 62 (1938 a). Number III is the section line, details of which are illustrated on page 334 of volume 63 (1939). Section lines IV and V are dealt with respectively on pages 297 and 299 of volume 65 (1941 a), and VI is detailed on page 348 of volume 62 (1938 b). Number VII is dealt with in the Trans. A.N.Z.A.A.S., pages 79-88, volume 24 (1939). The interval between section lines VII and VI indicated as VIII is now dealt with in this paper.

It will be observed that, taken together, the data of VII, VIII and VI constitute a complete cross-section of the Flinders Ranges (note the traverse A to B), which goes far to explain the structure of the whole mountain system in that region.

Therefore, to begin with, we will record the nature of the outcrops along the section line VIII, which will be considered in the three following sections.

The portion VIII A is a traverse across the Proterozoic glacial and fluvio-glacial beds from the tillite itself up to the first notable calcareous horizon.

That indicated as VIII B is a region of poor relief, presenting only limited opportunities for properly deciphering the rock structures and sequence of beds. The uppermost deposit is tillite, which overlies irregularly a region of slates, dolomite and basic igneous rocks. The tillite appears to overlie the other formations unconformably.

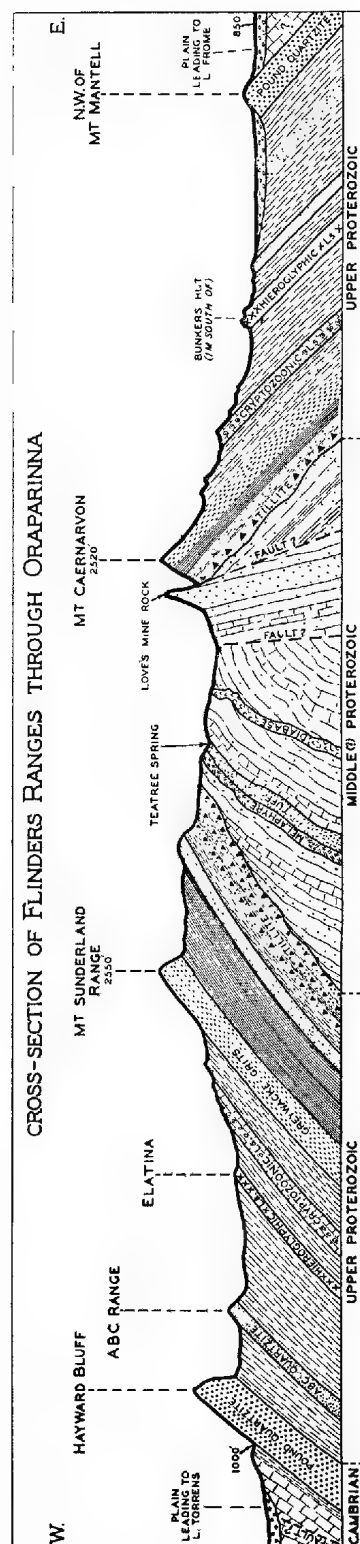
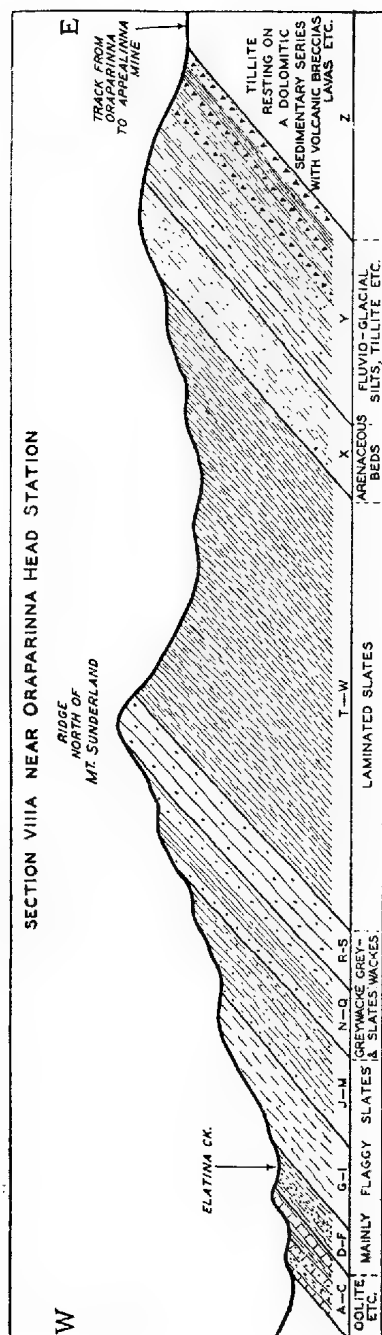
Finally, the portion VIII C connects the, as yet unresolved, central region VIII B with the Mount Caernarvon quartzite. It is thus the downward extension of the Mount Caernarvon Series as published (1938b). Descriptive details of each of these three subdivisions of section VIII now follow.

#### SECTION VIII A

At its downward limit the Brachina Creek section (VIII) ends at the summit of the Mount Sunderland ridge, which is near the central region of a domed formation of Pre-Cambrian glacial and post-glacial sediments. In 1939, with a view to ascertaining the sedimentary succession below the Mount Sunderland arkosic quartzite and greywacke, a further reconnaissance was made across the strata on the section line indicated on the map as VIII A, located somewhat to the north of the earlier section line VII. As a result, a continuous sequence of beds was established along a somewhat staggered line of outcrop down to the actual glacial horizon at a point about two miles S.S.E. of Oraparinna Head Station.

The new section now detailed actually overlaps portion of the original Brachina Creek section (VII), for item (15) of the latter is (A) of this section. The strata are recorded below in downward succession.

Item	True Thickness	Nature of the Strata
A	80 ft.	—Arenaceous limestone, calcareous sandstone, a band of limestone several feet thick showing cryptozoonic markings, and finally a thin stratum of oolitic limestone at the bottom of this division. Dip 15° to N.55°W. (mag.).
B	144 ft.	—Arenaceous impure limestone above to argillaceous limestone below.
C	72 ft.	—Somewhat calcareous argillaceous flags above, passing down into arenaceous limestone with some argillaceous bands. Dip 18°.
D	90 ft.	—Slates.
E	93 ft.	—Sandstone.
F	93 ft.	—Flaggy slates. The flags break out each several inches thick. Dip 18°.
G	65 ft.	—Argillaceous slates with some siltstone flags at intervals.
H	230 ft.	—Thick-bedded flaggy slate above to thin-bedded slate below. Dip 23°. In the lower part of this section flags 4 inches in thickness alternate with bands 6 to 12 inches in thickness of thin-splitting slate.
I	210 ft.	—Flaggy slate. Dip 20°.
J	110 ft.	—The upper limit is a bar of exceedingly fine-grained arkosic quartzite; below this are argillaceous flagstones, a further bar of fine-grained arkosic quartzite, more flagstones and at the base an arkosic quartzite formation 30 ft. thick.



Item	True Thickness	Nature of the Strata
K	126 ft.—	Arenaceous, flaggy argillite. Dip 21°.
L	200 ft.—	Laminated slates, faintly calcareous. Dip 18°.
M	17 ft.—	Argillaceous limestone.
N	126 ft.—	Light-grey to dark-grey fine-grained greywacke. Concretionary nodules occur near the base of this formation.
O	124 ft.—	Very fine-grained silty greywacke. This is massive in outcrop but the process of weathering renders obvious a fine lamination.
P	17 ft.—	Massive greywacke, strongly resistant to weathering.
Q	32 ft.—	Ripple-marked beds; flaggy argillite above and laminated slates below.
R	40 ft.—	Massive fine-grained greywacke.
S	255 ft.—	Flaggy to massive greywacke. This bed corresponds in part to item (1) of the Brachina Creek section (Mawson 1939 a, p. 81).

Down to this point all the above beds are represented in varying forms in the strata listed in the Brachina Creek section. Items (1) to (15) inclusive of that section amount to 2,199 feet in total thickness, in comparison with which the corresponding items (A) to (S) of this section aggregate in thickness 2,094 feet.

Below this point come the strata enumerated as (T) to (Y), which are the downward extension of the same series below the horizon of the Mount Sunderland greywacke.

Item	True Thickness	Nature of the Strata
T	776 ft.—	Slates, finely laminated. Dip 17°; strike N.50°E. (mag.).
U	240 ft.—	Slaty siltstone and arenaceous slates.
V	173 ft.—	Slates, finely laminated. Dip 18°.
W	1,000 ft.—	Slates, somewhat arenaceous above, then less arenaceous and again somewhat arenaceous near the base.
X	500 ft.—	Arenaceous beds incorporating some strong beds of greywacke siltstone.
Y	1,000+ft.—	Below the arenaceous horizon of (X) are fluvio-glacial beds leading to true tillite. Included are argillites which bulk most abundantly in the upper section, occasional arenaceous beds, some intercalations of fine-grained glacial mud, and, finally, unsorted tillite. In the downward succession, the first clear evidence of glacial transport appears at an horizon some hundreds of feet below the base of (X).

These glaciogene beds (below (X)) were traced down, for a thickness of not less than 1,000 feet, into low country with poor exposures unsuited for the prosecution of a rapid, and, at the same time, critical examination of their structural and petrological features. The bulk of this section of strata, though glaciogene in origin, has been deposited in water; only at the base does anything resembling tillite appear, and even then no really thick formation of breccia typically facial in character was encountered.

Z is an underlying formation apparently unconformably disposed to the overlying beds. Some account of its nature is given under the section VIII B.

### SECTION VIII C

Since the publication of the sequence of beds in the Mount Caernarvon block (Mawson 1938b) the extension of the succession to the west has been cursorily investigated. To the west from the summit of the Mount Caernarvon ridge, the

surface of the ground falls steeply until abutting against a lofty quartzite ridge known as Love's Mine Rock. This latter is a striking outcrop more than a mile in length composed of quartzite which everywhere dips steeply and in places is almost vertically disposed; it trends approximately in a meridional direction, ranging from a few degrees east to a little west of true north. It is almost as high as Mount Caernarvon itself and for the most part rises abruptly from low country.

Love's Mine Rock is not conformable with the Mount Caernarvon series of beds and is either part of an earlier formation or is a dislocated portion of a still lower section of the Mount Caernarvon beds. That the latter is so is likely because of considerable variation in dips and strikes in beds adjacent to this quartzite monolith. In the centre of the mass a dip of  $75^{\circ}$  to  $N.10^{\circ}W.$  (true) was recorded.

It is estimated that in the face of the steep slope below the summit of the Mount Caernarvon ridge and extending to the quartzite of Love's Mine Rock, a thickness of about 1,000 feet of sedimentary strata is represented. This is an approximation, but has not been accurately measured. Apart from the Mount Caernarvon greywacke-quartzite at the top, this column of strata, where examined, is composed mainly of flaggy slates which dip  $45^{\circ}$  to the east and strike  $N.12^{\circ}E.$  (true). However, as the base is approached some bands appear of a definitely fluvio-glacial nature. Then at the base, just above Love's Mine Rock quartzite, massive tillite was observed at a point where a stream following a fault line cuts across the quartzite from the east to the west side. The tillite exposed at that spot is quite characteristic and contains abundant erratics up to eighteen inches or more in diameter; boulders of quartzite, porphyry, granite, mica schist and basalt were noted; one of the basalt erratics collected is well faceted and striated.

Thus it is now shown that the sedimentary series which when first recorded (Mawson 1938b) was referred to as the Mount Caernarvon Series continues downwards for about another 1,000 feet below the horizon of Mount Caernarvon and passes into tillite. This succession is therefore another illustration of the nature of the post-glacial Proterozoic sediments laid down within the region of South Australia.

It is to be observed that the nature and thickness of the corresponding sediments on the western flank of the Range (Brachina Creek Series) agrees in general with those of the eastern flank. Comparing the thickness of sediments on either side of the Range between the upper limit of the glacial horizon and the lowest well-defined chocolate shale horizon we note the following.

In the east, at Mount Caernarvon, the beds represented below item (35) (Mawson 1938b) and down to and inclusive of (1), which is the Mount Caernarvon quartzite, total 6,287 feet. Below this, to the top of the first appearance of definite tillite as recorded above, is a further section of about 1,000 feet of beds; making the total thickness, from the chocolate horizon to the tillite, about 7,287 feet.

On the western side of the ranges in the Mount Sunderland locality, the beds from item (39) (Mawson 1938a) to and inclusive of (1) amount to 4,339 feet. The additional items (T) to (X), detailed earlier in this record, amount to 2,689 feet, making a total of 7,028 feet to the base of the arenaceous formation (X). Add to this about 700 feet of glaciogene beds below (X) before the first meeting of tillite in the division (Y), and the total becomes 7,728 feet, which corresponds to the 7,287 feet in the neighbourhood of Mount Caernarvon.

#### SECTION VIII B

This portion of the traverse across the ranges deals with sediments which predate the tillite and are much disturbed and faulted, and with which are associated basic igneous rocks, some of which are intrusive as dykes and possible necks. Tuffaceous breccias and scoriaceous melaphyre are also met with and

appear to have originated as volcanic effusions. Later on in this account more will be said concerning these igneous rocks. No detailed investigation of this division of the rock formations has yet been undertaken, but casual observation has disclosed the presence of a notable amount of dolomite, from the outcrops of which are shed occasional lumps of magnesite. In one place east of Teatree Spring there was observed an occurrence of sandy shale with casts of both former dolomite crystals and halite crystals, attesting aridity at the time of deposition.

It has been shown (Mawson 1941b) that in the Copley district the tillite is underlain without any really obvious break in the succession, by a richly dolomitic series of sediments. However, in that area, fragments of the underlying series are contained in the overlying tillite, so that an erosion interval is indicated, though possibly of very short duration. Where examined near Copley, no igneous rocks were observed associated with the dolomites. However, from Wooltana Station on the eastern flank of the range near its northern extremity there have been described (Mawson 1926) melaphyres and diabases associated with calcareous and dolomitic beds underlying the tillite. It appears, therefore, that the rocks of the central region at Oraparinna are similar to and comparable with the rocks below the tillite at Wooltana.

In the latter locality, the tillite has resulted from the erosive work of a land ice-sheet capping a region of former marked volcanic activity. There the base of the tillite is unconformable in relation to the underlying series. The same appears to apply at Oraparinna but is not so clearly marked. At Oraparinna the dolomitic series has been much disturbed and intruded by volcanic activity prior to the period of glacial erosion.

A special feature in this area is the occurrence of strong mineral vein formations rich in micaceous haematite with which are associated quartz, siderite and dolomite. Veins rich in baryte have also been encountered. At the spot indicated on the map by the mark X, located to the north of Pantapinna Spring, there is a notable vein of excellent light grey-blue asbestos, which recalls the occurrence of asbestos in the Wooltana igneous area.

Around and especially to the west of Blinman, is another region of dolomitic sediments invaded by basaltic intrusions. It is a repetition of the Oraparinna centre-country, and has been recorded by Howchin (1922).

## THE IGNEOUS ROCKS OF THE CENTRAL FLINDERS RANGES

Within the area now under consideration, the only igneous rocks are basic or near-basic lavas, dolerites, breccias and tuffs. These, for the most part, are grouped in two localities: firstly around Blinman as a centre, and secondly within a limited radius eastward of Oraparinna Head Station. Examples of occurrences in the Blinman area collected by Howchin (1922) have been described by Benson (1909).

Since that time we have located many outcrops of basic igneous rocks occurring in a belt of country with a roughly north to south trend, situated between Mount Caernarvon and Oraparinna Head Station. These are mainly compact or amygdaloidal melaphyres, but dolerites are well represented. One example encountered just east of Teatree Spring is extremely coarse-grained and approximates to gabbro; to this the term gabbroid dolerite could be applied. All have suffered mineral changes to a more or less degree; thus uralitization, saussuritization, epidotization and chloritization are regular features, while scapolite makes its appearance in some cases.

A melaphyre (No. 4,937) occurring *in situ* in considerable amount at about six miles from Oraparinna Head Station on the track to the Bunkers Hut, has

been selected for analysis as typical of the magma involved in these outbursts. The analysis below (I) included herewith was executed by E. G. Robinson, who had also assisted me in field work in that area. The composition is that of a typical basalt. In the hand specimen it is very fine-grained and uniform in character and of a reddish chocolate colour. Microscopically examined it is seen to have been rich in minute felspar laths and magnetite and to have embodied considerable augite. But it is now greatly changed and much clouded with haematite stains. Chlorite and leucoxene are abundant.

Related and apparently contemporaneous volcanic activity has been recorded in the neighbourhood of Woollana and Parallana, some 68 miles to the north-east of Blinman, by Mawson (1939 and 1926) and Woolnough (1926).

Apart from the Oraparinna and the Blinman igneous centres such rocks have not been located *in situ* elsewhere within the area of the map accompanying this contribution, excepting on the eastern flank of the Bunkers Range to the south-west of Old Wirrealpa Station buildings. Howchin (1922) was the first to record the existence of such in this region. The basalts and dolerites of this locality occur as dykes and as sheets conformable with the bedding of the adjacent beds. One of the reported occurrences in this area may prove to be a volcanic neck. The period of igneous activity in this locality apparently post-dates at least the main outbursts in the Blinman-Oraparinna areas, for they are associated with Cambrian Archaeocyathinae-bearing sediments. Also the specimens examined from this area have suffered a less degree of mineral change. An example to illustrate the character of the magma of these outpourings was collected *in situ* adjacent to the Blinman-Wirrealpa Road at a point 7 miles from Wirrealpa Head Station. An analysis of this rock executed by R. H. Jones, who accompanied me on a visit to the area, is quoted below (II).

The rock (No. 2,581) is of a fine even-grained texture, very dark-coloured and dense; specific gravity 3.05. It is a dolerite which has undergone partial amphibolitization. Relics of original ophitic structure are still preserved. The felspar was a medium labradorite but is in process of change. Cores of unaltered pyroxene of the composition of augite are surrounded by secondary amphibole. This latter is strongly zoned, being colourless or nearly so in the centre and strongly pleochroic in yellow-green to blue-green on the rim. The optical characters indicate tremolitic amphibole in the central areas to a sodic variety without. The amphibole has a general brown appearance in transmitted light owing to abundant very fine inclusions of particles of iron ore. Epidote and chlorite are present in the rock only in very small quantity. Original ilmenite has been converted to leucoxene.

	I	II		I	II
SiO <sub>2</sub> -	47.20	49.40	Na <sub>2</sub> O -	3.43	2.72
TiO <sub>2</sub> -	1.80	1.02	K <sub>2</sub> O -	2.76	0.38
Al <sub>2</sub> O <sub>3</sub> -	14.65	14.42	H <sub>2</sub> O+ -	2.46	1.36
Fe <sub>2</sub> O <sub>3</sub> -	11.55	2.75	H <sub>2</sub> O- -	0.49	0.12
FeO -	3.71	8.87	P <sub>2</sub> O <sub>5</sub> -	0.37	0.06
MnO -	0.04	not det.	CO <sub>2</sub> -	0.08	---
MgO -	6.61	7.38			
CaO -	5.39	11.75		100.54%	100.23%

- I. Melaphyre from near Teatree Spring about 5 miles from Oraparinna Head Station on the track to Bunkers Hut. Rock No. 4,937, analysed by E. G. Robinson, B.Sc.
- II. Meta-dolerite from the north side of the Blinman to Wirrealpa road at about 7 miles from Wirrealpa Head Station. Rock No. 1,258, analysed by R. H. Jones, B.Sc.

## OROGENY

Two distinct orogenic episodes operated in the development of the present orographic features. To begin with, at some time in the early Palaeozoic, probably in later Cambrian times, the enormously thick mass of Proterozoic and early Cambrian sediments which had accumulated in a great south to north trending geosyncline off the east coast of Pre-Cambrian ancestral Australia was buckled and folded on a grand scale.

In all probability peneplanation of this early-Palaeozoic mountain chain was far advanced by the end of Triassic time. Subsequent to this, as the result of a second period of diastrophism, the region now constituting the Flinders Range was raised as a horst block above the level of its surroundings; erosion has since brought into relief the present topographic features, though evidence of former peneplanation has not been obliterated. There is for instance, a general accordance of summit level over long distances in the case of ridges constituted of the harder sediments. Excellent examples of the kind are the level summit line of Freeling Heights, 3,120 feet above sea level, and of the Wilyerpa Range, about 2,900 feet above sea level, flanking the Bibliando Dome.

By analogy with the Mount Lofty Ranges whose history closely follows that of the Flinders Ranges, the period of commencement of block elevation should be referred to the later Pliocene. However, a greater degree of erosion appears to have taken place in the case of the latter, so the inception of block elevation in that locality may have antedated that of the Mount Lofty Ranges.

The trough faulting, which threw down and preserved the Triassic Leigh Creek coal basin, was a forerunner of the subsequent meridional faulting responsible for the present elevated mountain block. Though it is obvious that on either side of the ranges longitudinal faults exist in the plains country, now hidden beneath subsequent sedimentary depositions, yet the great face on the western flank between the Wilperna Pound Range and Mount Samtuel is not, in itself, a fault scarp comparable with the faces of the fault block of the Mount Lofty Ranges. Throughout most of its length that great wall is actually the dip face of the massive Pound Sandstone formation; stratigraphically above it rest the comparatively soft Cambrian shale and Archaeocyathinae limestone which, in large measure, have been removed by erosion bringing the massive Pound Sandstone into strong relief.

There have been observed some lines of major faulting of much greater age than the comparatively recent system of meridional trend associated with the uplift of the main horst block. The most notable of these lies north of the area included in the map on page 263. It passes the neighbourhood of Aroona Waters to the west of Copley and extends across the ranges in the vicinity of Mount Hack and towards Mount Roebuck. Another notable fault line roughly parallel to this truncates the Pound Sandstone at Wirrealpa Hill adjacent to Old Wirrealpa Station. An extensive zone of crushing at Mount John also illustrates faulting on a large scale. Such fault lines are very ancient, predating the period of peneplanation and in all probability developed in the early Palaeozoic mountain-building period.

However, it is not faulting that is responsible for much of the most striking orographic relief of the central and northern Flinders Ranges. This has mainly resulted from the denudation of a remarkably folded and thick series of sediments in which are contained not only massive beds, very hard and resistant to erosion, but also there are, sandwiched into the series, major formations of an unusually soft nature. Thus there are very thick arenaceous formations, in part converted to hard quartzite, and at the other extreme, recurrent formations all of considerable thickness of soft chocolate shales in part tuffaceous. As a con-



sequence, the processes of erosion have developed deep valleys and high crest lines. Thus the uplifted peneplane had been very deeply etched and the character of the folding developed in the piling up of these sediments into an early-Paleozoic mountain chain is clearly demonstrated. This is a region eminently suited for aerial survey.

In that ancient, mountain-building period the sediments involved were thrown into a series of long parallel folds in the more southerly areas affected; well exhibited in the region between Port Pirie and Mount Bryan. Further north, more especially above the line joining Wilson and Baratta, cycloclinal folding was developed. The most striking example of centroclinal structure is the basin range known as Wilpena Pound. Another such is developed in the Angepena system of hills north of Patawarta. Mern Merna is another such basin which is rendered unsymmetrical by a downthrow of the western portion of faulting. The Chace and Druid Ranges form an almost closed structure but this is actually a narrow synclinal basin, partially blocked by faulting at its eastern end.

Periclinally dipping domed structures are also well represented. In the region between Mount Sunderland and Patawarta, the sediments have been raised up to form a grand dome in the form of two linked subsidiary partial domes as shown in the map herewith. Other examples to be mentioned are the Bibliando Dome between Wilyerpa Hill and Baratta and the Mount Grainger Dome.

In the case both of periclinal and cycloclinal structures where there are elements in the sedimentary series differing widely in their resistance to erosion, there are developed by the processes of erosion, ring-shaped enclosures from which effluent streams escape through narrow breaches in the encircling wall. These structures are a feature of the Flinders Ranges of South Australia. The local pastoral community has applied to these land forms the term "pound," having reference to the application of the term to a place of confinement for animals.

It is obvious that this term "pound" may have useful application in descriptive geomorphology; to be distinguished as periclinal or domed pounds and centroclinal or basin pounds.

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1926. \*CHAPMAN, F., A.L.S., "Hellas," 50 Stawell Street, Kew E4, Victoria.  
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### FELLOWS.

1935. ADAM, D. B., B.Agr.Sc., Waite Institute (Private Mail Bag), Adelaide—**Council**, 1939-42; **Vice-President**, 1942-; **Librarian**, 1942-.
1925. ADEY, W. J., M.A., C.M.G., 32 High Street, Burnside, S.A.
1927. \*ALDERMAN, A. R., Ph.D., M.Sc., F.G.S., Div. Econ. Chemistry, C.S.I.R., Box 4331, G.P.O., Melbourne, Victoria—**Council**, 1937-42.
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1935. \*ANDREWARTHA, Mrs. H. V., B.Agr.Sc., M.S., 29 Claremont Avenue, Netherby, S.A.
1929. ANGEL, F. M., 34 Fullarton Road, Parkside, S.A.
1939. \*ANGEL, Miss L. M., M.Sc., University, Adelaide.
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1932. BEGG, P. R., D.D.Sc., L.D.S., 219 North Terrace, Adelaide.
1939. \*BERNDT, R. M., S.A. Museum, Adelaide.
1928. BEST, R. J., M.Sc., F.A.C.I., Waite Institute (Private Mail Bag), Adelaide.
1946. BIRCH, L. C., B.Agr.Sc., M.Sc., Waite Institute (Private Mail Bag), Adelaide.
1934. BLACK, E. C., M.B., B.S., Magill Road, Tranmere, Adelaide.
1907. \*BLACK, J. M., A.L.S., 82 Brougham Place, North Adelaide—**Vercò Medal**, 1930; **Council**, 1927-1931; **President**, 1933-34; **Vice-President**, 1931-33.
1940. BONYTHON, Sir J. LIVINGTON, 263 East Terrace, Adelaide.
1923. BURDON, R. S., D.Sc., University, Adelaide, S.A.
1922. \*CAMPBELL, T. D., D.D.Sc., D.Sc., Dental Dept., Adelaide Hospital, Adelaide—**Council**, 1928-32, 1935, 1942-; **Vice-President**, 1932-34; **President**, 1934-35.
1929. CHRISTIE, W., M.B., B.S., Education Department, Adelaide—**Treasurer**, 1933-8.
1895. \*CLELAND, Prof. J. B., M.D., University, Adelaide—**Vercò Medal**, 1933; **Council**, 1921-26, 1932-37; **President**, 1927-28; 1940-41; **Vice-President**, 1926-27, 1941-42.
1929. CLELAND, W. P., M.B., B.S., M.R.C.P., Dashwood Road, Beaumont.
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1929. \*COTTON, B. C., S.A. Museum, Adelaide.
1924. DE CRESPIGNY, Sir C. T. C., D.S.O., M.D., F.R.C.P., 219 North Terrace, Adelaide.
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1927. \*DAVIES, Prof. E. H., Mus.Doc., The University, Adelaide.
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 1917. \*FENNER, C. A. E., D.Sc., 42 Alexandra Av., Rose Park, Adelaide—**Council**, 1925-28; **President**, 1930-31; **Vice-President**, 1928-30; **Secretary** 1924-25; **Treasurer**, 1932-33; **Editor**, 1934-37.  
 1935. \*FENNER, F. J., M.B., B.S., 42 Alexandra Avenue, Rose Park. (A.I.F. abroad.)  
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 1921. \*JOHNSTON, PROF. T. H., M.A., D.Sc., University, Adelaide—**Verco Medal**, 1935; **Council**, 1926-28, 1940-; **Vice-President**, 1928-31; **President**, 1931-32; **Secretary** 1938-40; **Rep. Fauna and Flora Board**, 1932-39.  
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 1922. \*MADIGAN, C. T., M.A., B.E., D.Sc., F.G.S., Sch. Milit. Eng., Liverpool, N.S.W.—**Council**, 1939-33; **Vice-President**, 1933-35, 1936-37; **President**, 1935-36.  
 1933. MAGAREY, MISS K. de B., B.A., B.Sc., 19 Ashbourne Avenue, Mitcham, S.A.  
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 1938. \*MAWSON, MISS P. M., M.Sc., University, Adelaide.  
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 1934. MCCLOUGHRY, C. L., B.E., A.M.I.E. (Aust.), Town Hall, Adelaide.  
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 1925. \*PRESCOTT, PROF. J. A., D.Sc., A.I.C., Waite Institute (Private Mail Bag), Adelaide—**Verco Medal**, 1938; **Council**, 1927-30, 1935-39; **Vice-President**, 1930-32; **President**, 1932-33.  
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